MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE.

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INTRODUCTION.

The MONTHLY WEATHER REVIEW for April, 1897, is based on 2,927 reports from stations occupied by regular and voluntary observers, classified as follows: 143 from Weather Bureau stations; numerous special river stations; 33 from post surgeons, received through the Surgeon General, U. S. Army; 2,588 from voluntary observers; 96 received through the Southern Pacific Railway Company; 14 from Life-Saving stations, received through the Superintendent United States Life-Saving Service; 32 from Canadian stations; 1 from Hawaii; 20 from Mexican stations. International simultaneous observations are received from a few stations and used together with trustworthy newspaper extracts and special reports.

The REVIEW is prepared under the general editorial supervision of Prof. Cleveland Abbe. Unless otherwise specifically noted, the text is written by the Editor, but the meteorological tables contained in the last section are furnished by Mr. A. J. Henry, Chief of the Division of Records and Meteorological Data. Special acknowledgment is made of the hearty cooperation of Prof. R. F. Stupart, Director of the Meteorological Service of the Dominion of Canada, Mr. Curtis J. Lyons, Meteorologist to the Government Survey, Honolulu, and Dr. Mariano Bárcena, Director of the Central Meteorological Observatory of Mexico.

CLIMATOLOGY OF THE MONTH.

GENERAL CHARACTERISTICS.

The month was remarkable for the continued excess of rainfall in the Valley of the Mississippi and its tributaries, and for the consequent steady increase of dangerous floods in these rivers, a full account of which is given in the chapter on Rivers and Floods. A remarkable rise in barometric pressure occurred in Washington and Oregon, characteristic of the establishment of the summer season but at a much earlier date than usual. The temperature was above normal over the Lake Region and New England, and over Alberta, Saskatchewan, and Manitoba in Canada; the accumulated departures from normal temperature show that the Mississippi Valley and Lake Region already have a surplus of heat that will produce a continued warm soil and rapid vegetation during the summer unless abnormal conditions intervene.

ATMOSPHERIC PRESSURE.

[In inches and hundredths.]

The distribution of mean atmospheric pressure reduced to sea level, as shown by mercurial barometers, not reduced to standard gravity, and as determined from observations taken daily at 8 a. m. and 8 p. m. (seventy-fifth meridian time), is shown by isobars on Chart IV. That portion of the reduction to standard gravity that depends on latitude is shown by the numbers printed on the right-hand border.

The *mean pressure* during the current month was highest on the coast of Washington and Oregon, and almost as high on the coasts of North and South Carolina. It was lowest in Arizona and almost as low in Saskatchewan. The highest reduced pressures were: In the United States, Tatoosh Island, 30.18; Eureka, 30.17; Seattle, Hatteras, Charleston, 30.16; Lynchburg, Raleigh, Wilmington, and Fort Canby, 30.15. In Canada, White River, 30.10; Calgary, 30.05; Port Arthur, 30.04; Bermuda, 30.16. The lowest were: In the United States, Phœnix, 29.87; Yuma, 29.88; El Paso, 29.94; Havre, 29.97. In Canada, Prince Albert, 29.89; St. Johns, 29.94; Battleford and Medicine Hat, 29.98.

As compared with the normal for April, the mean pressure was generally in excess throughout the United States and Canada. The greatest excesses were: In the United States, Tatoosh Island, Erie, and Hatteras, 0.16; Block Island, Atlantic City, Lynchburg, and Norfolk, 0.15; Kittyhawk, Raleigh, and Wilmington, 0.14. In Canada, Halifax, 0.16; Sydney, 0.14; Calgary, 0.13. The deficits were: In the United States, Yuma, 0.03. In Canada, Swift Current, 0.01; Winnipeg, 0.03.

As compared with the preceding month of March, the pressures reduced to sea level show a rise throughout the United States, except in Florida and Arizona, but a fall over the northern Slope and Canadian Northwest Provinces. The greatest rises were: In the United States, Tatoosh Island, 0.31; Fort Canby, 0.27; Seattle, 0.26; Portland, Oreg., 0.20. In Canada, Esquimault, 0.29; St. Johns, 0.17. The greatest falls were: In the United States, Winnemucca, 0.11; Havre, 0.10; Miles City, 0.09; Moorhead, 0.08; Bismarck, Yuma, and Phœnix, 0.07. In Canada, Prince Albert, 0.20; Battleford, 0.14; Swift Current, 0.13.

AREAS OF HIGH AND LOW PRESSURE.

By Prof. H. A. HAZEN.

During the month of April eleven high areas and seven low areas were sufficiently well defined to be charted and their paths, together with the pressure near the center at 8 a. m. and 8 p. m., will be found in Charts I and II. The accompanying table gives the principal facts regarding the place of origin and disappearance of each high and low, and also the duration and length of each path with the velocity. A rather permanent area of high pressure in the Pacific Ocean caused six of the highs of the month. Two began in the region to the north of Montana, one in North Dakota,

and two near Lake Superior. Only six of the highs reached the Atlantic, one was last noted in the central part of the Gulf of Mexico, and the rest lost their identity or were merged in other highs in the interior. The general tendency of the highs was toward a translation along the northern border of the country. The more marked characteristics of the highs were the greater number and better definition than in the past six months.

The lows were affected by the permanent high just mentioned, as none had their beginning in the Pacific. Five were first noted to the north of Montana, one in Oregon, and two in Arizona. The translation of the lows was mostly along the northern border. Five of the lows reached the north Atlantic Coast, one disappeared north of Lake Superior, and the other two in the St. Lawrence Valley.

The highest wind of the month, 68 miles per hour on the 18th, at Chicago, was in connection with storm V, when it was central in north Michigan. This storm was rather remarkable in that it had a well-developed oval and very steep barometric gradients, but no rain fell till it reached the lower Lakes and then only in slight sprinkles. It was of a class of storms previously described which are quite prevalent in April and May in the Northwest, but without precipitation. The lowest pressure, but one, of the month, 29.18 inches, at Prince Albert p. m. of 21st, occurred in the center of low area VI, and this storm also had little or no precipitation in the Northwest. As low area No. VIII passed over Qu'Appelle the lowest pressure of the month, 29.12 inches, was noted there, p. m. of the 26th. The storm also had very steep gradients and a well formed oval but without precipitation till it reached the upper Mississippi Valley where there were only sprinkles.

Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long W.	Length.	Duration.	Daily.	Hourly.
High areas.		°	°		°	°	*Miles.*	*Days.*	*Miles.*	*Miles.*
I	1, a. m.	50	85	4, p. m.	40	70	1,060	3.5	303	12.6
II	5, a. m.	52	112	8, a. m.	48	62	2,270	3.0	758	31.6
III	5, p. m.	37	124	11, p. m.	29	81	3,770	6.0	628	26.2
IV	9, a. m.	50	90	13, p. m.	46	59	2,180	4.5	485	20.2
V	9, p. m.	42	127	15, a. m.	36	91	2,960	5.5	539	22.5
VI	13, p. m.	49	129	19, a. m.	32	80	3,800	5.5	691	28.8
VII	18, a. m.	52	109	22, p. m.	41	68	2,630	4.5	584	24.3
VIII	20, a. m.	40	127	27, a. m.	29	88	3,670	7.0	525	21.9
IX	26, a. m.	48	99	28, a. m.	39	80	1,140	2.0	570	23.8
X	26, p. m.	48	128	30, a. m.	51	83	2,010	3.5	574	23.9
XI	28, a. m.	41	129	30, p. m.	39	99	1,720	2.5	686	28.6
Total							27,210	47.5	6,343	
Mean of 11 paths							2,474	4.3	577	24.0
Mean of 45.5 days									573	23.9
Low areas.										
I	1, p. m.	33	111	7, a. m.	48	56	3,290	5.5	587	24.4
II	5, p. m.	33	114	10, p. m.	45	61	3,650	5.0	730	30.4
III	9, p. m.	53	117	14, a. m.	48	76	2,870	4.5	639	26.6
IV	12, p. m.	54	112	18, a. m.	48	62	2,700	5.5	491	20.5
V	15, p. m.	54	109	20, a. m.	46	58	2,650	4.5	588	24.5
VI	18, p. m.	43	130	23, a. m.	49	89	2,030	4.5	452	18.8
VII	23, p. m.	54	105	28, a. m.	41	69	2,660	4.5	591	24.6
VIII	25, p. m.	51	112	*	44	77	3,450	8.5	406	16.9
Total							23,240	42.5	4,484	
Mean of 8 paths							2,905	5.3	560	23.3
Mean of 42.5 days									547	22.8

*May 4, a. m.

TEMPERATURE OF THE AIR.

[In degrees Fahrenheit.]

Both the mean temperatures and the departures from the normal are given in Table I for the regular stations of the Weather Bureau, which also gives the height of the thermometers above the ground at each station. The mean temperature is given for each station in Table II, for voluntary observers.

The *monthly mean temperatures* published in Table I, for the regular stations of the Weather Bureau, are the simple means of all the daily maxima and minima; for voluntary stations a variety of methods of computation is necessarily allowed, as shown by the notes appended to Table II.

The *regular diurnal period* in temperature is shown by the hourly means given in Table V for 29 stations selected out of 82 that maintain continuous thermograph records.

The *distribution of the observed monthly mean* temperature of the air over the United States and Canada is shown by the dotted isotherms on Chart IV; the lines are drawn over the Rocky Mountain Plateau region, although the temperatures have not been reduced to sea level, and the isotherms, therefore, relate to the average surface of the country occupied by our observers; such isotherms are controlled largely by the local topography, and should be drawn and studied in connection with a contour map.

The *highest mean temperatures* were: In the United States, Key West, 75.5; Yuma, 72.4; Jupiter, 71.5; Corpus Christi, 70.4; Tampa, 70.3. In Canada, Bermuda, 65.0; Esquimault, 46.3; Halifax, 40.3; Toronto, 42.0; Port Stanley, 41.4; Kingston and Ottawa, 40.8; Montreal, 41.1. The lowest were: In the United States, Sault Ste. Marie, 36.9; Eastport, 38.6; Marquette, 37.8; Duluth, 40.0. In Canada, Father Point, 32.8; White River, 30.1; Quebec, 35.9; Port Arthur, 35.0.

As compared with the normal for April the mean temperature for the current month was in excess slightly on the Pacific and Atlantic coasts and appreciably over the Lake Region, New England, and Nova Scotia. It was slightly deficient throughout the Mississippi watershed and its tributaries and in the Canadian Northwest Provinces.

The greatest excesses were: In the United States, Moorhead, 4.4; Boston, 3.9; Sacramento, 3.1; Baker City, 3.0; Red Bluff, 2.7; Northfield, 2.6. In Canada, Yarmouth, 4.2; Halifax, 2.9; Rockliffe, 2.8; Port Stanley, 2.2. The largest deficits were: Cheyenne, 3.1; Springfield, Ill., 2.5; Springfield, Mo., 2.2. In Canada, Swift Current, 1.1; Qu'Appelle, 0.7; Medicine Hat, 0.4.

Considered by districts the mean temperatures of the current month show departures from the normal as given in Table I. The greatest positive departures were: New England, 1.6; North Dakota and Middle Pacific, 1.8; northern Plateau, 1.5. The greatest negative departures were: Florida Peninsula and southern Slope, 1.2; east Gulf, 1.6.

In Canada.—Prof. R. F. Stupart says:

> Over the greater part of the Dominion the mean temperature was higher than the average by between 1° and 4°, but in Algoma, Nipissing, and parts of eastern Quebec it was lower than the average by from 1° to 3°. In Alberta, Saskatchewan, and Manitoba the excess was between 3° and 4°.

The years of highest and lowest mean temperatures for April are shown in Table I of the REVIEW for April, 1894. The mean temperature for the current month was the highest on record at: Sacramento, 62.6, and Boston, 49.0. It was the lowest on record at: Amarillo, 55.3.

The *maximum and minimum temperatures* of the current month are given in Table I. The highest maxima were: 100, Yuma (17th); 96, Phœnix (18th); 94, San Luis Obispo (10th), Fresno (16th); 93, Abilene (7th), Red Bluff (25th); 92, San Antonio (7th); 90, Los Angeles (10th), Roseburg (15th), Williston (26th), Moorhead (27th). The lowest maxima were: 59, Eastport (29th); 61, Nantucket (30th); 62, Block Island (30th); 65, Woods Hole (30th); 66, Sault Ste. Marie (22d), Port Angeles (25th); 68, Narragansett Pier (30), Tatoosh Island (15th). The highest minima were: 66, Key West (17th); 59, Jupiter (11th); 53, Port Eads (10th); 52, Corpus Christi (9th); 50, Galveston (9th), New Orleans

(10th). The lowest minima were: 5, Sault Ste. Marie (19th); 9, Marquette (19th); 10, Alpena (19th); 12, Northfield (20th); 14, Duluth (19th); 15, Eastport (20th); 16, Moorhead (19th).

The *limits of minimum temperatures*, 32° and 40°, are shown by lines on Chart No. V.

The *years of highest maximum and lowest minimum temperatures* for April are given in the last four columns of Table I of the REVIEW for 1896. During the current month the maximum temperatures were equal to or above the highest on record at: Red Bluff, 93; Roseburg, 90; Portland, Oreg., 89; Northfield, 82; Fort Canby, 80; Astoria and Point Reyes Light, 78; Lander, 76; Tatoosh Island, 68. The minimum temperatures were not the lowest on record at any regular station of the Weather Bureau.

The *greatest daily range of temperature and the data for computing the extreme and mean monthly ranges* are given for each of the regular Weather Bureau stations in Table I. The largest values of the greatest daily ranges were: Marquette, 53; Williston, 51; San Luis Obispo, 50; Northfield, Winnemucca, and Carson City, 45; Lander, 44.

Among the *extreme monthly ranges* the largest were: Moorhead, 74; Williston and Northfield, 70; Huron, 66; Marquette, 65; Duluth and Pueblo, 64. The smallest values were: Key West, 18; Jupiter, 24; Port Eads, 26; Tatoosh Island, 30; Galveston and Corpus Christi, 31.

Accumulated monthly departures from normal temperatures from January 1 to the end of the current month are given in the second column of the following table, and the average departures are given in the third column for comparison with the departures of current conditions of vegetation from the normal condition.

Districts.	Accumulated departures.		Districts.	Accumulated departures.	
	Total.	Average.		Total.	Average.
	°	°		°	°
New England	+ 5.2	+ 1.3	North Dakota	— 7.0	— 1.8
Middle Atlantic	+ 2.9	+ 0.7	Northern Slope	— 4.6	— 1.2
South Atlantic	+ 1.0	+ 0.2	Southern Plateau	— 5.1	— 1.3
Florida Peninsula	+ 2.5	+ 0.6	Middle Plateau	— 9.3	— 2.4
East Gulf	+ 0.6	+ 0.1	North Pacific	— 1.4	— 0.4
West Gulf	+ 5.2	+ 1.3	Middle Pacific	— 4.0	— 1.0
Ohio Valley and Tenn	+ 2.4	+ 0.6	South Pacific	— 2.9	— 0.4
Lower Lake	+ 5.2	+ 1.3			
Upper Lake	+ 8.8	+ 2.2			
Upper Mississippi Valley	+ 2.6	+ 0.6			
Missouri Valley	+ 0.5	+ 0.1			
Middle Slope	+ 1.5	+ 0.4			
Northern Plateau	+ 4.5	+ 1.1			
Southern Slope	+ 0.0	+ 0.0			

PRECIPITATION.

[In inches and hundredths.]

The *distribution of precipitation* for the current month, as determined by reports from about 2,500 stations, is exhibited on Chart III. The numerical details are given in Tables I, II, and III. The total precipitation for the current month exceeded 6 inches in the greater portion of southern Louisiana, southeastern Missouri, central Iowa, southern Illinois, Indiana, Tennessee, and Kentucky, as also in southern Nova Scotia.

The larger values for regular stations were: Port Eads, 11.70; Jupiter, 8.47; Tatoosh Island, 7.61; Cairo, 6.49.

Little or no rain fell in southern California, Nevada, Arizona, New Mexico, and western Texas.

Details as to *excessive precipitation* are given in Tables XI and XII.

The *years of greatest and least precipitation* for April are given in the REVIEW for April, 1890. The precipitation for the current month was the greatest on record at: Port Eads, 11.70; Jupiter, 8.47; Des Moines, 7.37; Vineyard Haven, 5.95; Oklahoma, 5.87; Alpena, 4.59; Concordia, 4.20. It was the least on record at: Los Angeles and San Diego, 0.02; Carson City, 0.03; Point Reyes Light and Port Angeles, 0.48; Cleveland, 1.34.

The *diurnal variation*, as shown by tables of hourly means of the total precipitation, deduced from the self-registering gauges kept at the regular stations of the Weather Bureau, is not now tabulated.

The *average departure* for each district is given in Table I. By dividing each current precipitation by its respective normal the following corresponding percentages are obtained (precipitation is in excess when the percentage of the normal exceeds 100):

Above the normal: New England, 121; Florida Peninsula, 315; east Gulf, 130; Ohio Valley and Tennessee, 112; upper Lake, 126; upper Mississippi Valley, 127; Missouri Valley, 137; middle Slope, 148.

Normal: Southern Plateau, 100.

Below the normal: Middle Atlantic, 77; south Atlantic, 91; west Gulf, 60; lower Lake, 87; North Dakota, 59; northern Slope, 75; southern Slope, 50; middle Plateau, 56; northern Plateau, 76; north Pacific, 61; middle Pacific, 39; south Pacific, 11.

The *current departures* from the normal precipitation are given in Table I, which shows that precipitation was in excess in the east Gulf States, the Tennessee and Ohio valleys, the Mississippi and lower Missouri valleys, the central Lakes, the St. Lawrence Valley, New England, and Nova Scotia. It was deficient in the west Gulf States, the Rocky Mountain Plateau and Pacific Coast regions. The large excesses were: Port Eads, 8.7; Jupiter, 6.0; Des Moines, 4.6. In Canada, Yarmouth, 4.2; Halifax, 2.9; Rockliffe, 2.8; Port Stanley, 2.2. The large deficits were: Kittyhawk and Astoria, 3.1; Cape Henry, 3.0; Norfolk and Fort Canby, 2.6. In Canada, Swift Current, 1.1.

The *total accumulated monthly departures* from January 1 to the end of the current month are given in the second column of the following table: The third column gives the percentage of the current accumulated precipitation relative to its normal value.

Districts.	Accumulated departures.	Accumulated precipitation.	Districts.	Accumulated departures.	Accumulated precipitation.
	Inches.	*Per ct.*		*Inches.*	*Per ct.*
Florida Peninsula	+ 4.40	141	New England	— 1.70	86
East Gulf	+ 1.00	105	Middle Atlantic	— 2.80	80
Ohio Valley and Tenn	+ 2.80	117	West Gulf	— 0.90	94
Upper Lake	+ 0.50	105	Lower Lake	— 0.80	92
North Dakota	+ 0.80	119	North Pacific	— 0.80	97
Upper Mississippi Valley	+ 4.10	147	Middle Pacific	— 1.10	93
Missouri Valley	+ 3.50	148			
Northern Slope	+ 0.40	111			
Middle Slope	+ 1.90	136			
Abilene (southern Slope)	+ 0.50	115			
Southern Plateau	+ 1.50	176			
Middle Plateau	+ 0.90	116			
Northern Plateau	+ 0.20	103			
South Pacific	+ 1.20	176			
South Atlantic	+ 0.00	100			

MOISTURE.

The *quantity of moisture* in the atmosphere at any time may be expressed by the weight of the vapor coexisting with the air contained in a cubic foot of space, or by the tension or pressure of the vapor, or by the temperature of the dew-point. The mean dew-point for each station of the Weather Bureau, as deduced from observations made at 8 a. m. and 8 p. m., daily, is given in Table I.

The *rate of evaporation* from a special surface of water on muslin at any moment determines the temperature of the wet-bulb thermometer. The mean wet-bulb temperature is now published in Table I; it is always intermediate, and generally about half way between the temperature of the air

and of the dew-point. The quantity of water evaporated in a unit of time from the muslin surface may be considered as depending essentially upon the wet-bulb temperature, the dew-point, and the wind.

The *relative humidity*, or the ratio between the moisture that is present in the air and the moisture that it would contain if saturated at its observed temperature is given in Table I as deduced from the 8 a. m. and 8 p. m. observations. The general average for a whole day or any other interval would properly be obtained from the data given by an evaporometer, but may also be obtained, approximately, from frequent observations of the relative humidity.

SNOWFALL.

The *total monthly snowfall* at each station is given in Tables I and II; its geographical distribution is shown on Chart V. This chart also shows the isotherms of minimum 32° and of minimum 40° for the air within the ordinary thermometer shelter. The former isotherm is an approximate limit to possible snow, while the latter is an approximate southern limit to the regions that report frost in exposed localities.

Snowfalls are reported as follows: 1 to 15 inches in northern New England and western Nebraska; 1 to 6 in northern New York and Ohio; 1 to 9 in northern Michigan and Wisconsin; 1 to 13 in the Dakotas. In the Rocky Mountain Region the highest reported snowfalls were: Colorado, 40; Nevada and California, 16; Oregon, 36; Washington, 14.

The *depth of snow on the ground* at the end of the month is usually shown on Chart VI; it is also shown on the weekly charts of the Climate and Crop Service. At the close of April the snow was confined to isolated mountainous regions and is, therefore, not charted.

In Canada.—The following items are gathered from the map for April published by Prof. R. F. Stupart:

British Columbia, the first appearance of Pacific Coast summer type of weather was on April 11, as compared with June 13, 1896. In Osoyoos and Okanagan, after March the weather turned suddenly mild and snow disappeared; everything more advanced than usual. Nicola, snow had gone by the 10th and plowing began. Lower mainland, fruit trees promising good crops, owing to unusual warmth and consequent disappearance of the snow. Northwest Territories and Manitoba, Red River Valley, owing to the melting of an unusually large accumulation of snow, much damage has been done by flooding. Calgary, snow has disappeared. Battleford, vegetation is slow, considering the length of time since the snow melted. Quebec, snow all gone on the 22d.

ICE.

The *thickness of ice* in the rivers and harbors is shown in detail in the bulletins published by the Weather Bureau every Monday during the winter months. No special reports are at hand for April.

In Canada.—Prof. R. F. Stupart reports:

At the close of the month, Calgary, the river is low and free from ice. Prince Albert, river opened on the 19th and is very high. Quebec, navigation opened on the 25th. Charlottetown, P. E. I., ice in the harbor began to break up on the 13th. St. John, N. B., navigation opened on the St. John River on the 24th.

HAIL.

The following are the dates on which hail fell in the respective States:

Alabama, 3, 8, 30. Arizona, 26. Arkansas, 3, 7, 8, 13, 29. California, 1, 19, 20, 26, 27. Colorado, 7, 23, 24, 27, 28, 29, 30. Connecticut, 28. Florida, 9, 15, 19. Georgia, 5, 6, 9, 29, 30. Idaho, 5, 6, 20, 21. Illinois, 8, 16, 18, 22, 23, 24. Indiana, 11, 13, 16, 23. Indian Territory, 1, 3, 8, 9, 13. Iowa, 4, 16, 20 to 24, 28. Kansas, 1, 2, 3, 6, 8, 9, 19, 21 to 24, 27, 28. Kentucky, 8, 11, 16, 19, 26, 30. Louisiana, 2, 3, 5, 6, 9, 28, 29. Massachusetts, 28. Michigan, 4, 13, 23, 25, 26. Minnesota, 9, 21, 27. Mississippi, 1, 3, 29. Missouri, 1, 3, 7 to 10, 12, 13, 19, 20, 22, 23, 28, 29. Montana, 1, 10, 29. Nebraska, 1, 3, 8, 9, 20 to 24, 28. New Jersey, 5. New Mexico, 26. New York, 5, 17, 19, 22, 23. North Carolina, 5, 8. North Dakota, 3, 4, 5, 7, 10, 11. Ohio, 5, 11, 13, 16, 19, 23, 30. Oklahoma, 1, 7, 9, 13, 23, 27. Oregon, 4, 5, 6, 19, 21, 26. Pennsylvania, 5, 6, 16, 19, 26. Rhode Island, 6. South Carolina, 5, 26. South Dakota, 8, 27. Tennessee, 4, 5, 8, 11, 29. Texas, 6, 7, 13, 14, 21. Utah, 1 to 4, 7, 20, 22. Virginia, 16. Washington, 4, 6, 21. Wisconsin, 21, 24. Wyoming, 20.

SLEET.

The following are the dates on which sleet fell in the respective States:

Colorado, 6, 23. Connecticut, 28. Idaho, 4, 5. Illinois, 1, 7, 9, 12, 16, 20, 23. Indiana, 8, 9, 16. Iowa, 1, 9, 10, 20. Kentucky, 16. Maine, 9. Massachusetts, 27. Michigan, 6, 7, 9, 16, 18, 29, 30. Minnesota, 5, 8, 11. Missouri, 3, 8, 10, 19, 20. Nebraska, 1, 2, 7, 8, 19, 28. Nevada, 1, 6, 19 to 23, 27. New Hampshire, 5, 11, 27. New York, 7, 9, 17, 27. North Carolina, 1, 2, 10. Ohio, 7 to 11, 13, 16, 17, 20, 21. Oregon, 2, 6. Pennsylvania, 26, 27. South Dakota, 5, 12, 27, 28. Tennessee, 9. Utah, 6, 24. Vermont, 9. Wisconsin, 2, 5, 7, 12, 13, 15, 23, 30.

WIND.

The *prevailing winds* for April, 1897, viz, those that were recorded most frequently, are shown in Table I for the regular Weather Bureau stations.

The *resultant winds*, as deduced from the personal observations made at 8 a. m. and 8 p. m., are given in Table VIII. These latter resultants are also shown graphically on Chart IV, where the small figure attached to each arrow shows the number of hours that this resultant prevailed, on the assumption that each of the morning and evening observations represents one hour's duration of a uniform wind of average velocity. These figures indicate the relative extent to which winds from different directions counterbalanced each other.

HIGH WINDS.

Maximum wind velocities are given in Table I, which also gives the altitudes of the Weather Bureau anemometers above the ground. Maxima of 50 miles or more per hour were reported during this month at regular stations of the Weather Bureau as follows (maximum velocities are averages for five minutes; extreme velocities are gusts of shorter duration, and are not given in this table):

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Miles				*Miles*	
Amarillo, Tex	7	56	n.	Dodge City, Kans	28	50	n.
Do	11	54	n.	El Paso, Tex	2	60	sw.
Do	23	60	se.	Fort Canby, Wash	21	52	s.
Do	28	58	n.	Lincoln, Nebr	28	50	n.
Buffalo, N. Y	19	54	w.	New York, N. Y	26	50	nw.
Do	26	54	w.	Do	27	58	nw.
Carson City, Nev	6	59	w.	Sioux City, Iowa	18	54	nw.
Chicago, Ill	18	67	s.	Do	27	52	s.
Do	22	53	s.	Tatoosh Island, Wash	16	55	e.
Do	23	50	s.	Winnemucca, Nev	6	60	nw.

ATMOSPHERIC ELECTRICITY.

Numerical statistics relative to auroras and thunderstorms are given in Table IX, which shows the number of stations from which meteorological reports were received, and the number of such stations reporting thunderstorms (T) and auroras (A) in each State and on each day of the month, respectively.

Thunderstorms.—The dates on which the number of reports of thunderstorms for the whole country were most numerous were: 5th, 152; 8th, 127; 23d, 159; 24th, 131. Reports were most numerous in: Illinois, 155; Iowa, 114; Louisiana, 105; Missouri, 176.

Thunderstorm days were most numerous in: Florida, Kan-

sas, and Louisiana, 19 days; Iowa, 17; Nebraska and Texas, 18; Illinois, 20; Missouri, 23.

Auroras.—The evenings on which bright moonlight must have interfered with observations of faint auroras are assumed to be the four preceding and following the date of full moon, viz, from the 12th to the 20th, inclusive. On the remaining twenty-one days of this month 228 reports were received, or an average of about 11 per day. The dates on which the number of reports of auroras for the whole country especially exceeded this average were: 1st, 86; 5th, 19; 23d, 30.

Reports were most numerous in. Michigan, 27; Minnesota, 23; New Hampshire and Ohio, 18; New York, 26; North Dakota, 35.

The number of reports was a large percentage of the number of observers in: North Dakota, 90; New Hampshire, 78; Minnesota, 33; Michigan and New York, 28.

CANADIAN REPORTS.

Thunderstorms were reported as follows: Father Point, 23d; Quebec, 23d; Montreal, 23d, 25th; Rockliffe, Toronto, Kingston, Port Stanley, 23d; Saugeen, 4th; Parry Sound, 24th; Port Arthur, 22d; Winnipeg, 18th, 24th.

Auroras were reported as follows: Halifax, 16th; Grand Manan, 24th; Yarmouth, 1st; St. Andrews, 20th; Father Point, 1st, 27th; Quebec, 1st, 3d, 23d; Montreal, 1st; Toronto, 1st; White River, 1st, 4th, 5th; Port Stanley, 1st: Saugeen, 1st; Port Arthur, 6th, 14th, 24th; Winnipeg, 1st, 2d, 4th, 7th, 20th, 23d, 24th; Minnedosa, 1st, 7th, 9th, 12th, 16th, 19th, 24th, 25th, 26th, 29th; Qu'Appelle, 16th; Medicine Hat, 23d, 24th, 27th; Calgary, 9th; Prince Albert, 2d, 16th, 24th, 30th; Battleford, 7th; Banff, 20th, 21st; Sable Island, 1st.

SUNSHINE AND CLOUDINESS.

The quantity of sunshine, and therefore of heat, received by the atmosphere as a whole is very nearly constant from year to year, but the proportion received by the surface of the earth depends upon the absorption by the atmosphere, and varies largely with the distribution of cloudiness. The sunshine is now recorded automatically at 22 regular stations of the Weather Bureau by its photographic, and at 37 by its thermal effects; at one of these stations records are kept by both methods. The photographic record sheets show the apparent solar time, but the thermometric records show seventy-fifth meridian time; for convenience the results are all given in Table X for each hour of local mean time. In order to complete the record of the duration of cloudiness these registers are supplemented by special personal observations of the state of the sky near the sun in the hours after sunrise and before sunset, and the cloudiness for these hours has been added as a correction to the instrumental records, whence there results a complete record of the duration of sunshine from sunrise to sunset.

The average cloudiness of the whole sky is determined by numerous personal observations at all stations during the daytime, and is given in the column "average cloudiness" in Table I; its complement, or percentage of clear sky, is given in the last column of Table X.

COMPARISON OF DURATIONS AND AREAS.

The sunshine registers give the *durations* of effective sunshine whence the durations relative to possible sunshine are derived; the observers' personal estimates give the percentage of *area* of clear sky. These numbers have no necessary relation to each other, since stationary banks of clouds may obscure the sun without covering the sky, but when all clouds have a steady motion past the sun and are uniformly scattered over the sky, the percentages of duration and of area agree closely. For the sake of comparison, these percentages have been brought together, side by side, in the following table, from which it appears that, in general, the instrumental records of percentages of durations of sunshine are almost always larger than the observers' personal estimates of percentages of area of clear sky; the average excess for April, 1897, is 9 per cent for photographic and 8 per cent for thermometric records.

The details are shown in the accompanying table, in which the stations are arranged according to the *total possible* duration of sunshine, and not according to the *observed* duration.

Difference between instrumental and personal observations of sunshine.

Stations.	Latitude.	Apparatus.	Total possible duration for the whole month.	Personal estimated area of clear sky.	Instrumental record of sunshine.			
					Photographic.	Difference.	Thermometric.	Difference.
	° ′		*Hrs.*	%	%	%	%	%
Tampa, Fla	27 57	T.	385.4	50	.....	.....	54	+ 4
Galveston, Tex	29 18	P.	386.4	64	72	+ 8	.....	.....
New Orleans, La	29 58	T.	387.4	32	.....	.....	32	0
Savannah, Ga	32 05	P.	389.9	53	61	+ 8	.....	.....
Vicksburg, Miss	32 22	T.	389.9	75	.....	.....	78	+ 3
San Diego, Cal	32 43	P.	390.5	75	76	+ 1	.....	.....
Charleston, S. C.	32 47	T.	390.5	61	.....	.....	70	+ 9
Phœnix, Ariz	33 28	P.	390.5	89	95	+ 6	.....	.....
Atlanta, Ga	33 45	T.	391.6	54	.....	.....	59	+ 5
Los Angeles, Cal	34 03	P.	391.6	69	80	+11	.....	.....
Wilmington, N. C.	34 14	T.	391.6	62	.....	.....	69	+ 7
Little Rock, Ark	34 45	T.	392.7	47	.....	.....	68	+21
Chattanooga, Tenn	35 04	T.	392.7	47	.....	.....	54	+ 7
Santa Fe, N. Mex	35 41	P.	393.6	62	73	+11	.....	.....
Raleigh, N. C.	35 45	T.	393.6	57	.....	.....	76	+19
Nashville, Tenn	36 10	T.	393.6	54	.....	.....	60	+ 6
Fresno, Cal	36 43	T.	394.8	88	.....	.....	93	+ 5
Dodge City, Kans	37 45	P.	396.2	57	66	+ 9	.....	.....
San Francisco, Cal	37 48	T.	396.2	70	.....	.....	81	+11
Louisville, Ky	38 15	T.	396.2	40	.....	.....	55	+15
St. Louis, Mo	38 38	T.	397.0	38	.....	.....	52	+14
Washington, D. C	38 54	P.	397.0	60	67	+ 7	.....	.....
Kansas City, Mo	39 05	P.	397.0	40	48	+ 8	.....	.....
Cincinnati, Ohio	39 06	T.	397.0	44	.....	.....	49	+ 5
Baltimore, Md	39 18	T.	397.0	55	.....	.....	54	− 1
Atlantic City, N. J	39 22	P.	397.0	57	70	+13	.....	.....
Denver, Colo	39 45	P.	398.6	51	69	+18	.....	.....
Indianapolis, Ind	39 46	T.	398.6	39	.....	.....	50	+11
Philadelphia, Pa	39 57	T.	398.6	51	.....	.....	72	+21
Columbus, Ohio *	39 58	T.	.....	30	.....	.....	.....	.....
Pittsburg, Pa	40 32	T.	399.4	38	.....	.....	43	+ 5
New York, N. Y	40 43	T.	399.4	58	.....	.....	76	+18
Salt Lake City, Utah	40 46	P.	399.4	50	67	+17	.....	.....
Eureka, Cal	40 48	P.	399.4	51	60	+ 9	.....	.....
Cheyenne, Wyo	41 08	P.	399.4	52	60	+ 8	.....	.....
Omaha, Nebr	41 16	P.	399.4	41	50	+ 9	.....	.....
Cleveland, Ohio	41 30	T.	401.1	26	.....	.....	32	+ 6
Des Moines, Iowa	41 35	T.	401.1	44	.....	.....	47	+ 3
Chicago, Ill	41 53	T.	401.1	46	.....	.....	49	+ 3
Erie, Pa	42 07	T.	401.1	40	.....	.....	46	+ 6
Binghamton, N. Y	42 08	T.	401.1	42	.....	.....	48	+ 6
Detroit, Mich	42 20	T.	401.1	33	.....	.....	41	+ 8
Boston, Mass	42 21	T.	401.1	50	.....	.....	57	+ 7
Dubuque, Iowa	42 30	T.	401.1	49	.....	.....	44	− 5
Albany, N. Y	42 39	T.	.....	38	.....	.....	.....	.....
Buffalo, N. Y. †	42 53	T.	346.1	30	.....	.....	59	+29
Rochester, N. Y	43 08	T.	402.1	44	.....	.....	47	+ 3
Idaho Falls, Idaho	43 29	T.	402.1	72	.....	.....	64	− 8
Portland, Me	43 39	T.	403.6	49	.....	.....	63	+14
Northfield, Vt	44 10	P.	403.6	35	46	+11	.....	.....
Eastport, Me	44 54	P.	405.2	37	45	+ 8	.....	.....
St. Paul, Minn	44 58	P.	405.2	46	53	+ 7	.....	.....
Minneapolis, Minn	44 59	T.	405.2	.....	.....	.....	38	.....
Portland, Oreg	45 32	T.	407.0	60	.....	.....	61	+ 1
	45 32	P.	407.0	60	65	+ 5	.....	.....
Helena, Mont	46 34	P.	408.4	54	58	+ 4	.....	.....
Bismarck, N. Dak	46 47	P.	408.4	41	45	+ 4	.....	.....
Seattle, Wash	47 38	T.	410.4	57	.....	.....	57	0
Spokane, Wash. *	47 40	P.	.....	43	.....	.....	.....	.....

* Instrument out of order.
† 26 days only; the total possible for 30 days is 402.1; personal estimate, 33 per cent.

CLIMATE AND CROP SERVICE.

By JAMES BERRY, Chief of Climate and Crop Service Division.

The following extracts relating to the general weather conditions in the several States and Territories are taken from the monthly reports of the respective sections of the Climate and Crop Service. The name of the section director is given after each summary.

Snowfall and rainfall are expressed in inches.

Alabama.—The mean temperature was 62.2°, or 1.3° below normal; the highest was 91°, at Goodwater on the 28th, and the lowest, 29°, at Maple Grove on the 15th. The average precipitation was 4.12, or 1.00 below normal; the greatest monthly amount, 6.57, occurred at Daphne, and the least, 1.39, at Clanton.—*F. P. Chaffee.*

Arizona.—The mean temperature was 64.3°, or 4.7° above normal; the highest was 110°, at Fort Mojave on the 16th, and the lowest, 17°, at Whipple on the 1st. The average precipitation was 0.08, or 0.40 below normal; the greatest monthly amount, 1.00, occurred at Walnut Grove, while none fell at numerous stations.—*W. T. Blythe.*

Arkansas.—The mean temperature was 61.5°, or 1.3° below normal; the highest was 90°, at Stuttgart on the 27th, and the lowest, 31°, at Keesees Ferry on the 17th. The average precipitation was 4.14, or 0.78 below normal; the greatest monthly amount, 6.12, occurred at Mount Nebo, and the least, 1.93, at Fulton.—*F. H. Clarke.*

California.—The mean temperature was 60.6°, or 2.9° above normal; the highest was 112° at Salton and Volcano Springs on the 16th, and the lowest, 11°, at Bodie on the 9th. The average precipitation was 0.51, or 1.85 below normal; the greatest monthly amount, 3.70, occurred at North Bloomfield, while none fell at numerous stations.—*J. A. Barwick.*

Colorado.—The mean temperature was 43.0°, or 1.0 below normal; the highest was 87°, at Lamar on the 20th, and the lowest, 11° below zero, at Pagoda on the 1st. The average precipitation was 1.50, or 0.02 above normal; the greatest monthly amount, 10.50, occurred at Ruby, and the least, trace, at Saguache.—*F. H. Brandenburg.*

Florida.—The mean temperature was 70.2°, or 0.5° below normal; the highest was 94°, at Clermont on the 25th, at Earnestville on the 28th, and at Kissimmee on the 8th; the lowest was 37°, at Haywoods on the 11th. The average precipitation was 1.66 above normal; the greatest monthly amount, 10.55, occurred at Lemon City, and the least, 1.47, at Orange City.—*A. J. Mitchell.*

Georgia.—The mean temperature was 62.7°, or 0.8° below normal; the highest was 95°, at Belleville on the 28th, and the lowest, 27°, at Diamond on the 11th. The average precipitation was 3.81, or 0.15 above normal; the greatest monthly amount, 11.65, occurred at Clayton, and the least, 2.20, at Brag.—*J. B. Marbury.*

Idaho.—The mean temperature was 43.9°, or 3.1° above normal; the highest was 90°, at Payette on the 20th, and the lowest, 6°, at Lake on the 1st. The average precipitation was 1.02, or 0.66 below normal; the greatest monthly amount, 2.40, occurred at Murray, and the least, 0.02, at Burnside.—*D. P. McCallum.*

Illinois.—The mean temperature was 50.4°, or 1.6 below normal; the highest was 85°, at Albion on the 24th, and the lowest, 18°, at Dwight on the 20th. The average precipitation was 4.26, or 0.71 above normal; the greatest monthly amount, 8.31, occurred at Cobden, and the least, 1.88, at Ottawa and Streator.—*C. E. Linney.*

Indiana.—The mean temperature was 50.7°, or 2.0° below normal; the highest was 90°, at Salem on the 28th, and the lowest, 13°, at La Porte on the 20th. The average precipitation was 4.33, or 0.77 above normal; the greatest monthly amount, 9.93, occurred at Vincennes, and the least, 0.99, at Hammond.—*C. F. R. Wappenhans.*

Iowa.—The mean temperature was 47.9°, or about normal; the highest was 89°, at Fonda on the 23d and 27th, and the lowest, 19°, at Larrabee on the 19th. The average precipitation was 5.35, or 2.75 above normal; the greatest monthly amount, 9.86, occurred at Winterset, and the least, 2.22, at Northwood.—*G. M. Chappel.*

Kansas.—The mean temperature was 53.6°, or 2.2° below normal; the highest was 96°, at Meade on the 18th, and the lowest, 23°, at Coolidge and Goodland on the 14th. The average precipitation was 3.69, or 1.32 above normal; the greatest monthly amount, 7.17, occurred at Atchison, and the least, 1.35, at Paola.—*T. B. Jennings.*

Kentucky.—The mean temperature was 55.5°, or 1.3° below normal; the highest was 90° at Alpha on the 28th, and the lowest, 25°, at Eubank on the 10th and at Owenton on the 20th. The average precipitation was 6.03, or 1.67 above normal; the greatest monthly amount, 9.97, occurred at Canton, and the least, 2.96, at Carrollton.—*Frank Burke.*

Louisiana.—The mean temperature was 66.6°, or 2.1° below normal; the highest was 90°, at Donaldsonville on the 4th and 5th, and at Rayne on the 7th; the minimum was 34°, at Davis on the 17th. The average precipitation was 4.81, or 0.72 above normal; the greatest monthly amount, 12.40, occurred at Abbeville, and the least, 1.26, at Sugartown.—*R. E. Kerkam.*

Maryland and Delaware.—The mean temperature was 52.0°, or 0.4° above normal; the highest was 94°, at Taneytown on the 25th, and the lowest, 15°, at Sunnyside on the 20th. The average precipitation was 2.94, or 0.77 below normal; the greatest monthly amount, 5.06, occurred at Sunnyside, and the least, 2.00, at Solomons.—*G. E. Hunt.*

Michigan.—The mean temperature was 42.1°, or 2.0° below normal; the highest was 80°, at Allegan and Berrien Springs on the 28th, and the lowest, zero, at Newberry on the 19th. The average precipitation was 2.87, or 0.56 above normal; the greatest monthly amount, 5.90, occurred at Gladwin, and the least, 0.88, at Romeo.—*C. F. Schneider.*

Minnesota.—The average temperature was 43.7°, or 0.8° below normal; the highest was 92°, at Milaca on the 24th, and the lowest, 3° below zero, at Tower on the 19th. The average precipitation was 1.55, or 1.50 below normal; the greatest monthly amount, 3.54, occurred at Pleasant Mounds.—*T. S. Outram.*

Mississippi.—The mean temperature was 64.1°, or 0.6° below normal; the highest was 94°, at Fayette on the 24th and at Thornton on the 21st, and the lowest, 30°, at Corinth on the 18th and at French Camp on the 10th. The average precipitation was 2.87, or 3.56 below normal; the greatest monthly amount, 8.75, occurred at Bay St. Louis, and the least, 1.20, at Mayersville.—*R. J. Hyatt.*

Missouri.—The mean temperature was 54.2°, or 0.8° below normal; the highest was 88°, at Marshal on the 27th, and the lowest, 21°, at Potosi on the 17th. The average precipitation was 4.55, or 0.79 above normal; the greatest monthly amount, 8.21, occurred at Boonville, and the least, 1.20, at Emma.—*A. E. Hackett.*

Montana.—The mean temperature was 45.0°, or 1.0° above normal; the highest was 94°, at Glendive on the 26th, and the lowest, 7°, at Monarch on the 6th. The average precipitation was 1.05, or 0.13 below normal; the greatest monthly amount, 4.15, occurred at Fort Benton, and the least, 0.20, at Chinook and Manhattan.—*R. M. Crawford.*

Nebraska.—The mean temperature was 47.8°, or 2.2° below normal; the highest was 90°, at Brokenbow on the 17th and at Whitman on the 26th; the lowest was 8°, at Kimball on the 7th. The average precipitation was 3.82, or 1.41 above normal; the greatest monthly amount, 8.72, occurred at Wilber, and the least, 0.40, at Fort Robinson.—*G. A. Loveland.*

Nevada.—The mean temperature was 47.3°, or 0.5° above normal; the highest was 91°, at Downeyville on the 16th, and the lowest, 9°, at Gold Creek on the 7th. The average precipitation was 0.37, or about half the usual amount; the greatest monthly amount, 1.44, occurred at Crane's Ranch, while none fell at Mill City and Wadsworth.—*R. F. Young.*

New England.—The mean temperature was 46.1°, or 2.1° above normal; the highest was 88°, at Stratford, N. H., on the 25th, and the lowest, 3°, at Flagstaff, Me., on the 1st. The average precipitation was 2.97, or 0.02 below normal; the greatest monthly amount, 5.95, occurred at Vineyard Haven, Mass., and the least, 1.60, at Plymouth, N. H.—*J. W. Smith.*

New Jersey.—The mean temperature was 50.4°, or 0.7° above normal; the highest was 89°, at Beverly on the 25th, and the lowest, 19°, at Somerville on the 21st. The average precipitation was 3.79, or 0.43 above normal; the greatest monthly amount, 6.98, occurred at Staffordville, and the least, 2.17, at Egg Island.—*E. W. McGann.*

New Mexico.—The mean temperature was slightly below normal; the highest was 95°, at San Marcial on the 17th, and the lowest, 1°, at Gold Hill on the 9th. The average precipitation was about normal, but was very unevenly distributed; the greatest monthly amount, 2.20, occurred at Gold Hill, but none fell at Deming, Galisteo, and Lordsburg.—*H. B. Hersey.*

New York.—The mean temperature was 45.2°, or 1.5° above normal; the highest was 87°, at Port Jervis on the 25th, and the lowest, 3°, at Little Falls on the 19th. The average precipitation was 2.47, or 0.05 below normal; the greatest monthly amount, 4.90, occurred at Brentwood, and the least, 0.68, at Cortlandt.—*R. M. Hardinge.*

North Carolina.—The mean temperature was 57.6°, or 0.3° below normal; the highest was 91°, at Greensboro on the 30th, and the lowest, 22°, at Linville on the 21st. The average precipitation was 3.68, or 0.10 below normal; the greatest monthly amount, 10.57, occurred at Lynn, and the least, 0.98, at Edenton.—*C. F. Von Herrmann.*

North Dakota.—The mean temperature was 40.8°, or 0.6° below normal; the highest was 93°, at Power on the 27th, and the lowest, 7°, at Fargo on the 2d. The average precipitation was 1.01, or 1.67 below normal; the greatest monthly amount, 3.25, occurred at Fort Yates, and the least, trace, at Bordulac and Power.—*B. H. Bronson.*

Ohio.—The mean temperature was 49.3°, or 1.2° below normal; the highest was 92°, at Portsmouth on the 28th, and the lowest, 11°, at Ridgeville Corners on the 20th. The average precipitation was 3.27, or 0.30 above normal; the greatest monthly amount, 5.69, occurred at

Wauseon, and the least, 1.28, at St. Ignatius College (Cleveland).—*H. W. Richardson.*

Oklahoma.—The mean temperature was 59.9°; the highest was 97°, at Norman on the 20th, and the lowest, 28°, at Pond Creek on the 9th. The average precipitation was 5.38; the greatest monthly amount, 13.35, occurred at Edmonton, and the least, 0.80, at Fort Sill.—*J. I. Widmeyer.*

Oregon.—The mean temperature was 51.8°, or 4.0° above normal; the highest was 100°, at Vernonia on the 25th, and the lowest, 10°, at Fort Klamath on the 2d. The average precipitation was 1.84, or 1.95 below normal; the greatest monthly amount, 5.50, occurred at Government Camp, and the least, 0.15, at P. Ranch.—*B. S. Pague.*

Pennsylvania.—The mean temperature was 49.0°, or 1.1° above normal; the highest was 92°, at Gettysburg on the 25th, and the lowest, 12°, at Blooming Grove on the 20th. The average precipitation was 3.30, or 0.50 below normal; the greatest monthly amount, 4.63, occurred at Uniontown, and the least, 1.20, at Easton.—*T. F. Townsend.*

South Carolina.—The mean temperature was 62.2°, or 0.6° below normal; the highest was 95°, at Gillisonville on the 28th, and the lowest, 31°, at Walhalla on the 17th. The average precipitation was 3.24, or 0.10 above normal; the greatest monthly amount, 8.40, occurred at Walhalla, and the least, 1.41, at Gillisonville.—*J. W. Bauer.*

South Dakota.—The mean temperature was 44.7°, or 1.0° below normal; the highest was 91°, at Aberdeen and Mellette on the 27th, and the lowest, 10°, at Fort Meade on the 1st. The average precipitation was 2.95, or 0.40 above normal; the greatest monthly amount, 6.13, occurred at Greenwood, and the least, 0.60, at Farmingdale.—*S. W. Glenn.*

Tennessee.—The mean temperature was 58.1°, or 1.5° below normal; the highest was 88°, at Springdale on the 24th, at St. Joseph on the 27th, and at Byrdstown on the 28th; the lowest was 25°, at Erasmus on the 10th. The average precipitation was 6.18, or 1.83 above normal; the greatest monthly amount, 9.41, occurred at McKenzie, and the least, 2.84, at Elizabethton.—*H. C. Bate.*

Texas.—The mean temperature was 1.6° below normal; there was a general deficiency, except in the vicinity of Camp Eagle Pass and El Paso, where there was an excess of 1.9° and 0.5°, respectively; the deficiency ranged from 0.8° to 2.5° over northern and eastern sections, from 1.1° to 3.6° over central and southwest sections, and from 0.1° to 4.9° over the coast district, with the greatest deficit in the vicinity of Cuero; the highest was 101°, at Camp Eagle Pass on the 5th, and the lowest, 26°, at Valentine on the 1st. The average precipitation was 0.98 below normal; there was a general deficiency, except over the western part of the southwest section, the Panhandle, and in the vicinity of Luling and Cuero, where there was an excess ranging from 0.18 to 3.45, with the greatest at Luling; the deficiency ranged from 0.61 to 2.96 over northern and eastern sections, from 0.57 to 2.98 over central section, and from 0.06 to 3.14 over the coast district and the eastern part of southwest section, with the greatest excess in the vicinity of Houston; the greatest monthly amount, 5.70, occurred at Luling, while none fell at Dean, Midland, and Valentine.—*I. M. Cline.*

Utah.—The mean temperature was 47.0°; the highest was 93°, at St. George on the 16th, and the lowest, 6°, at Koosharem on the 1st. The average precipitation was 0.89; the greatest monthly amount, 3.25, occurred at Pahreah, and the least, trace, at Frisco.—*J. H. Smith.*

Virginia.—The mean temperature was 53.9°, or 2.0° below normal; the highest was 95°, at Farmville on the 23d, and at Bonair on the 25th, and the lowest, 18°, at Monterey on the 20th. The average precipitation was 2.08, or 0.95 below normal; the greatest monthly amount, 4.90, occurred at Guinea, and the least, 0.15, at Bedford City.—*E. A. Evans.*

Washington.—The mean temperature was 51.0°, or 3.4° above normal; the highest was 94°, at Chehalis on the 10th, and the lowest, 18°, at Cascade Tunnel on the 1st. The average precipitation was 1.68, or 1.84 below normal; the greatest monthly amount, 7.61, occurred at Tatoosh, and the least, trace, at Sunnyside.—*G. N. Salisbury.*

West Virginia.—The mean temperature was 51.5°, or about normal; the highest was 90°, at Hewett on the 28th, and the lowest, 19°, at White Sulphur Springs on the 19th and 20th. The average precipitation was 2.97, or slightly below normal; the greatest monthly amount, 7.10, occurred at Philippi, and the least, 1.58, at Bluefield.—*H. L. Ball.*

Wisconsin.—The mean temperature was 43.9°, or 1.5° below normal; the highest was 87°, at Osceola Mills on the 23d, and the lowest, 10°, at Crandon on the 19th, and at Spooner on the 1st. The average precipitation was 2.43, or 0.60 below normal; the greatest monthly amount, 4.89, occurred at Hartland, and the least, 0.10, at Spooner.—*W. M. Wilson.*

Wyoming.—The mean temperature was 42.1°, or 2.0° above normal; the highest was 86°, at Carbon on the 19th, and the lowest, 2°, at Wise on the 4th. The average precipitation was 0.89, or 0.90 below normal; the greatest monthly amount, 1.67, occurred at Sundance, and the least, 0.50, at Green River.—*M. G. Renoe.*

RIVER AND FLOOD SERVICE.

By PARK MORRILL, Forecast Official, in charge of River and Flood Service.

The highest and lowest water, mean stage, and monthly range at 118 river stations are given in the following table. Hydrographs for typical points on seven principal rivers are shown on Chart VI. The stations selected for charting are: Keokuk, St. Louis, Cairo, Memphis, and Vicksburg, on the Mississippi; Cincinnati, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

The flood in the lower Mississippi continued throughout April. At Cairo the river remained in high flood during the first half of the month, falling but 2 feet, but during the latter half it declined rapidly and reached the danger line on the 28th. At Memphis there was a very slow but steady fall during the entire month; the total change was only 2½ feet, and the water was still slightly above danger line on the 30th. The stage at Vicksburg was practically constant at its maximum during the latter half of the month, while at New Orleans a very slow but steady rise was still in progress at the close of the month.

At Memphis the height of the river during the present flood exceeded all previous records by 1.5 foot, and that in spite of vast overflows from the river through crevasses in the levees. A considerably higher stage would have been reached had the levees held. The river attained its maximum of 37.1 feet on March 20, at which point its rise was checked through the breaking of the levees near Nodena on the 19th. The rise continued at Cairo for a full week longer, and would probably have lasted at Memphis for ten days, except for the water taken from the river through the crevasses. At the time the levees broke the daily rise was about 0.4 foot.

The river at Vicksburg continued to rise until the 16th, when a stage of 52.3 feet was reached, 1.2 foot in excess of the previous high-water record. At New Orleans a stage of 19.3 feet had been reached at the close of the month, 1.4 foot higher than any water known before.

The Ohio was low during the early part of the month, rose to a good boating stage during the middle of the month, and again fell to a low stage at its close. The Tennessee continued in flood during the first half of April and was the chief agent in maintaining the Mississippi flood. The upper Mississippi was in moderate flood most of the month and the Missouri rose to a flood stage at its close. This resulted in moderately high water at St. Louis, which rose to danger line on the last day of the month.

The following résumé of river stages and conditions of navigation in the respective streams is compiled from reports by the officials of the Weather Bureau at various river stations and section centers:

Hudson River. (Reported by A. F. Sims, Albany, N. Y.)—The Hudson River was at its normal height on the first of the month and so continued up to the morning of the 7th. A 14-inch rise was noted at Albany on the 8th, so that comparatively deep water was to be found along the river front. The river continued to rise steadily during the 9th, and on the morning of the 10th the water was within 2 feet of the stringpiece of the bulkhead. A cold wave over the watershed of the Hudson on the night of the 10th was very effective in checking the flow of surface water, and by the morning of the 11th a fall of 12 inches was noted. The turbidity of the water caused companies pumping from the river to shut down during the first ten days of April.

Much of the rain which fell on the 15th found its way to the river very quickly, so that by the morning of the 16th a 12-inch rise was recorded. The peculiar color of the water points to the occurrence of the heaviest rainfall during the storm over the watershed of the Hoosic River. A gradual rise was experienced up to 8 a. m. of the 17th, when a stage of 7 feet was recorded at Albany. The resultant swift current caused not a little trouble, and many captains experienced difficulty in landing tows. The cold wave on the night of the 19th again checked the flow of water in the feeders of the upper Hudson and caused a gradual fall from the head of navigation south to Catskill, N. Y. By the morning of the 22d the current lessened perceptibly and the condition of the river permitted the commencement of dredging for the season. By the night of the 24th the river stage was once more normal.

Some light snows fell over the Hudson watershed on the morning of the 27th, and a fall of 8 inches was reported from the extreme north portion of the Adirondack section. On the 29th the annual log drive commenced on the Sacondaga River; log driving on the upper Hudson became general on the 30th, and log drivers are preparing to begin operations along the Cedar and Boreas rivers. The output of logs is exceptionally large this year.

Susquehanna River and branches. (Reported by E. R. Demain, Harrisburg, Pa.)—The rainfall for the month was less than normal over the section drained by the Susquehanna River, and consequently the stages of water in all streams of the system averaged lower than usual for this time of year, the average gauge reading at Harrisburg being nearly 2 feet lower than for the same month in the years 1895 and 1896.

The amount of precipitation from the general storm which passed over this section on the 9th averaged about 1.30 inch in the Susquehanna Basin. This caused a general and at most stations quite a decided rise; at Harrisburg the river rose 5.7 feet in three days, the highest point registered being 9.5 feet on the 12th. This flood afforded an excellent opportunity for timber men to get their logs to market and rafting was actively prosecuted during the week, or so, that the river continued high enough to float the timber.

Later rains caused a less important rise in the lower river, amounting to one foot at Harrisburg on the 17th and 18th, after which the river gradually fell and at the end of the month was about 2.5 feet lower than at the close of March.

Rivers of South Atlantic States. (Reported by E. A. Evans, Richmond, Va.; C. F. von Herrmann, Raleigh, N. C.; L. N. Jesunofsky, Charleston, S. C.; D. Fisher, Augusta, Ga.; and J. B. Marbury, Atlanta, Ga.)—The James River held at a low stage during the entire month, there being no rises of any consequence. The rainfall was less than the normal over a portion of the basin drained. In the upper James Valley, where the greater part of the rain fell, previous droughty conditions caused the soil to absorb a large quantity of the water and as a consequence but little was received by the stream. The water was unusually clear for the season. The highest reading recorded at Richmond during the month was 1.6 foot.

None of the rivers of North Carolina reached the danger line during the month of April. The early part of the month, up to the 12th, was comparatively rainy, with heavy precipitation on the 4th and 5th, and 9th and 10th, which during the winter, when the ground is unbroken or frozen, would have caused dangerous floods, but at present, falling on cultivated fields, only caused a slow and not dangerously high rise in the larger streams. The smaller watercourses overflowed their banks twice in the month, without much damage. The dry period at the close of the month brought all the rivers to low stages, and permitted the cultivation of lowlands.

The greatest rise in any of the South Carolina streams occurred at Cheraw on the 6th, resulting from the heavy rainfall over the northwestern portion of the State during the 4th and 5th. The gauge showed 9.5 feet at the 8 a. m. observation of the 5th, with a rise of 2.7 feet for the previous twenty-four hours. The river rose 21.7 feet during the afternoon and night of the 5th and up to 4 p. m. of the 6th, when a gauge reading of 4.2 feet above the danger line was recorded. The oat crop on lowlands was slightly damaged by the overflow. Driftwood was running heavily on the 6th and 7th. The crest of the flood waters passed Smiths Mills on the lower river on the 15th and 16th at a 16.8 foot stage, 0.8 foot above the danger line.

The Wateree at Camden reached the danger line early on the morning of the 6th and on the 7th was 4.6 feet above the danger line. The freshet damaged oats and wheat on lowlands. The drainage from the watersheds of the Broad and Saluda rivers raised the Congaree at Columbia to a stage 0.5 feet above the danger line on the 6th. The Lynch at Effingham rose 0.5 foot per day from the 6th to the 13th, exceeding the danger line by 0.3 foot on the latter date. The Santee at St. Stephens rose rapidly during the 11th to 14th, attaining a gauge reading of 11.5 feet on the 14th. Navigation was uninterrupted on all streams the entire month. The freshets on the upper streams in the early part of the month did not reach the coast region until the 20th. Rice planters were thus enabled to drain and prepare their lands for planting, which has been kept back three weeks.

The steady rain during the early part of April caused a small freshet in the Savannah River during the first ten days of the month, after which the water gradually receded. On the 6th a number of farms in the river bottoms were partially submerged, injuring the grasses that had started on their first growth, but the overflowed land will hardly reach 20 per cent of the entire area under cultivation. A good navigable stage of water was maintained during the entire month. Other sections of Georgia received about the normal amount of rain, and no marked rises occurred in the rivers during the month. There were some heavy rains which caused rises of several feet in the Chattahoochee, Oostanaula, and Flint during the first week, but a steady fall and very little rain is noted during the balance of April.

Mobile River and branches. (Reported by F. P. Chaffee, Montgomery, Ala., and W. M. Dudley, Mobile, Ala.)—Rains during the latter part of March and early in April caused steady but slow rises in the Alabama River and its tributaries during the first ten days of the month, followed by slowly falling waters to the 15th, when well distributed rains occasioned slight rises during the 16th and 17th. Then followed slowly falling waters to the 30th, when general rains over the watershed started another slow rise. As a whole, the month showed a decline in all the rivers of this system, though good navigable stages prevailed during the entire month. Much lowland that had been submerged by the high waters of March was drained off and prepared for crops.

The Tombigbee River and its tributaries continued at good navigable heights to the 20th, when owing to deficient rainfall a decline set in and the headwaters had become quite low at the close of the month. The rains which occurred during the month were mostly light and being rapidly absorbed by vegetation had but little effect on the rivers.

Ohio River and branches. (Reported by F. Ridgway, Pittsburg, Pa.; H. L. Ball, Parkersburg, W. Va.; S. S. Bassler, Cincinnati, Ohio; F. Burke, Louisville, Ky.; and P. H. Smyth, Cairo, Ill.)—For the greater part of the month the water has been too low to admit of coal shipments from Pittsburg. The general rains of the 8th, 9th, and 10th supplemented by the rains of the 15th and 16th, resulted in a good coal-boat stage which continued until the 20th instant. The operators of the upper river mines were thereby enabled to send out for lower ports about 10,000,000 bushels of coal, most of which passed through Pittsburg harbor on the 10th and 11th. The river remained open the entire month, however, for packets and other vessels of light draught and the companies operating such boats report that both freight and passenger traffic were above the average for April.

In the rivers of West Virginia unusually good boating stages existed throughout the month. A period of general and moderately heavy rains occurred from the 4th to the 16th and these caused a rise in all the rivers, but it was not great and did not interfere with navigation. The Ohio at Parkersburg reached its maximum stage, 21.8 feet, on the 12th. From that date until the close of the month the river fell slowly, reaching its lowest stage, 8.5 feet, on the 30th. The Great and Little Kanawa rivers held good boating stages throughout the month and navigation was unimpeded.

Beyond an excellent stage of water during nearly the entire month there was nothing of special importance in the condition of the Ohio River at Cincinnati. After the high waters of February and March the river gradually receded until about the 5th of April when it rose, reaching its maximum height for the month on the 15th. During the remainder of the month there was a steady fall, with indications of an early low-water season. River traffic to the south was almost suspended on account of the floods in the lower Mississippi.

Good stages for navigation prevailed at Louisville throughout the month. The heavy rains of the 8th and 9th caused the stream to swell several feet, the rise lasting to the 16th, after which the stage of water was slowly reduced until the close of the month.

At Evansville the river was above the danger line to the 3d, and from the 11th to the night of the 21st. A steady fall set in on the 19th and continued to the close of the month. At Paducah the river fell during most of the month. On the 18th the river got within its banks, and from then until the end of the month the fall averaged 1.3 foot daily.

At Cairo the river changed but very little during the first half of the month, at times remaining on a stand for one, two, or three days. During the last half of the month a steady fall was in progress, the river getting within its banks by the 28th, after being above the danger line since February 28. In the lower Ohio Valley many thousands of acres of wheat have been drowned out and ruined, and thousands of bushels of corn in cribs have been destroyed. The hay crop has been damaged to no inconsiderable extent. So far as can be ascertained the loss of stock has been small.

The seep water at Cairo, augmented by rain and waste water since the closing of the sewer outlets, reached its maximum stage on the 13th. Nearly all of the graded streets were covered or partly covered, and on many of the streets the sidewalks were several inches under water. A drainage pump, for the southeast portion of the town, was put in operation on the 12th and began to show its good effect by the 14th. By the 21st of the month the graded streets lying southeast of Twenty-first street, were free of water. The streets lying northwest of Twenty-first street were, at the close of the month, still under water in places. A second drainage pump, for the northwest portion, was put in operation on the 24th. All of the ungraded or unfilled portions of Cairo are still submerged at the end of the month.

This spring's flood attained a higher stage than has been reached at Cairo since February, 1884. On February 25–26, 1882, the river stood

at 51.9 feet. During this flood the river was above the danger line from the night of January 13 until the night of April 4. In 1883 the river reached its maximum stage of 52.2 feet on February 26–27; it was above the danger line from February 13 until March 11, from April 8 to April 20, and from April 24 to May 4. In the flood of 1884 the river reached a stage of 51.8 feet on the 21st, 22d, and 24th of February, and was above the danger line from February 7 until March 7, and from March 15 until April 11. The water this spring for the fourth time in thirty years, has reached a stage exceeding 51 feet.

Tennessee and Cumberland rivers. (Reported by L. M. Pindell, Chattanooga, Tenn., and H. C. Bate, Nashville, Tenn.)—Observations on the Tennessee River were discontinued at stations above Chattanooga after March 31. The Tennessee and its tributaries had been moderately low, except at points below Riverton, but began to rise on the 1st of April and continued rising until the 4th. Rockwood and Loudon sent special rainfall reports, showing 2.70 inches of rain at the former and 1.90 inch at the latter station. The river having reached 26.0 feet at Chattanooga by 8 a. m. of the 5th and the information received indicating another freshet, authority was obtained from the Chief of the Weather Bureau to resume full river reports over the system and the river observers at all stations, except Kingston, were instructed by telegraph to resume reports and to report the total rainfall from April 1 up to date. The reports received showed the heaviest rainfall to be along the Clinch and Hiawassee rivers, amounting to 4.71 inches at Kingston and 5.28 inches at Clinton. By the morning of the 7th the rivers were all falling and the special reports were discontinued. The highest water at Chattanooga was 30.8 feet at 6 p. m. on the 6th. After the 6th the river fell steadily, the lowest water for the month occurring on April 30. At Harriman, on the 4th, the Emory River reached 43 feet aud the situation was serious, forcing families to move and doing much damage. The Tennessee did not reach the danger line at any station from the headwaters to Bridgeport, Ala. The river rose at Florence, Ala., until the 10th; at Riverton, Ala., the third rise for the year began on April 3 and continued up to the 11th, when the gauge read 30.1 feet. Navigation was good during the entire month, except during the highest water, when boats did not venture out.

The month opened with the Cumberland River ranging from 6 feet at the headwaters to 16 feet at Nashville and rising slowly. Rain during the first week, especially at the headwaters, put the river at flood tide for the second time this year and produced a rise that for a time promised to equal the flood of the preceding month. At Burnside the river rose 48 feet in the 24 hours ending at 8 a. m. of the 5th and reached a maximum of 58.1 feet. A maximum of 42 5 feet was recorded at Carthage on the 7th and one of 42.3 at Nashville on the 10th. The river gradually subsided from the maximum above indicated and was falling for the balance of the month, except for a slight temporary rise during the last week. Good business was reported by rivermen at all points and the month closes with a favorable stage of water and a general rise at all points.

Mississippi River and minor branches. (Reported by P. F. Lyons, St. Paul, Minn.; M. J. Wright, Jr., La Crosse, Wis.; F. J. Walz, Davenport, Iowa; F. Z. Gosewisch, Keokuk, Iowa; H. C. Frankenfield, St. Louis, Mo.; S. C. Emery, Memphis, Tenn.; R. J. Hyatt, Vicksburg, Miss.; R. E. Kerkam, New Orleans, La.; and C. Davis, Shreveport, La.)—The Mississippi River continued above the danger line at St. Paul from the 1st to the 18th. Commencing on the 1st with a reading of 15.3, it continued rising until 18.0 feet was attained on the 6th, followed by a gradual and steady fall to the 30th, when the stage was 10.3 feet. The flood at St. Paul and for a considerable distance up the Mississippi and that in the Minnesota River are the first of serious consequence since 1881. Since the beginning of the river service at St. Paul in 1872, the gauge reading of 18 feet was equaled on April 16, 1875; it was exceeded on April 29, 1881, when the extreme stage of 19.7 feet was attained. Aside from some hardship and a little suffering and loss to about 300 families, most of whom were "squatters" on the river flats, no harm resulted. An enormous quantity of logs floated down the river daily up to the 14th, the amount varying from an occasional one to great confused masses which showed the effect of tremendous twisting and squeezing. The ice went out of Lake Pepin on the 5th and opened up the river to St. Paul, but the first boat, the U. S. snag boat *General Barnard*, did not arrive at St. Paul until the 20th.

The Chippewa gorge of ice and logs, which broke the latter part of March and lodged again near the mouth of the river, passed out of the Chippewa and down the Mississippi on the 3d. The material of this gorge continued down the river past La Crosse, and was finally broken up and scattered without doing any serious damage. A large amount of valuable lumber and logs is scattered through the woods below Lake Pepin on account of the water being so high, and most of it will be lost. The flood wave which passed St. Paul on the 6th reached Red Wing the 7th, falling 0.3 foot short of the danger line at that point; it reached Reeds Landing on the 8th, giving a stage of 0.3 foot above the danger line. After the flood crest had passed the river fell steadily the remainder of the month.

At La Crosse the Mississippi was above the danger line during the entire month, the gauge reading ranging from 10.0 feet to 13.7 feet. The crest of the flood wave passed on the 10th, the river having risen rapidly from the 1st to the 10th, and then falling gradually from the 10th to the 30th, the daily fall after the flood wave had passed amounting to 0.2 foot. The river has been too high for good navigation, but there has been considerable activity among steamboat and river men. From the 5th to the 19th the levee from State street to the wagon bridge was covered with several inches of water, and the tracks of the Chicago, Milwaukee, and St. Paul Railroad on Front street were submerged. Water flooded the basements of buildings on Front street. The occupants of buildings along the levee heeded the warnings of the approaching high water, which were issued by the Weather Bureau, and took the precaution to remove from their basements all goods that would be likely to suffer damage. The entire valley of the Mississippi in this vicinity, from bluff to bluff, averaging about 3 miles in width, was overflowed during the greater portion of the month, with the exception of a few high places.

The flood damage from Davenport northward was not very great, although considerable cultivated land was overflowed, because little work had yet been done in preparing the soil or planting crops. Then, as the flood subsided quickly, the water did not remain over the land long enough to injure it or prevent planting this year's crops. These lands are draining off rapidly and most of them will be sufficiently dry for putting in full crops yet this spring. The hay crop, which is the principal one raised on the overflowed lands, will not be injured at all by the overflow and, unless this flood is succeeded by another in May or June, the crop of hay harvested will be as good and as large as in former years.

The entire valley from Tempeauleau to Lansing, 63 miles in length and averaging about 2 miles in width, was overflowed. But in this district there is little land cultivated, it being low and subject to overflow. At Dubuque the water flooded the cellars of the buildings on lower Main street and the lower part of the city; it also flooded the lumber yards and flats, compelling many people of the poorer class to move. Many goods and a large amount of lumber had to be moved. From Clinton to Davenport there was little damage done and very little land overflowed, except islands and a district of some 6,000 or 8,000 acres of very fertile and highly cultivated lands at the mouth of the Wapsipinicon River. The damage here, however, will not be great, as farming operations had not begun and the water will recede and the land dry off in time to raise a crop. At Davenport and vicinity there was little damage done. Several of the large sawmill plants in Rock Island and Moline had to shut down for a short period on account of the high water; the mills in Davenport had not yet started up. Cellars of business houses near the river in both Davenport and Rock Island were flooded to a small extent and goods stored therein had to be moved. One line of railroad running into Davenport was obliged, for a week or so, to abandon its tracks, which enter the city along the levee, but its trains were moved over the tracks of other roads.

The heavy rains at the end of March swelled the Mississippi, already at a high stage, to the danger line at Keokuk by the evening of April 5. Lowlands near the mouth of the Des Moines were slightly overflowed, as well as some very low-lying lands in Clark County, Mo. On the 7th the river had fallen below the danger line and continued falling until the 12th, when the flood from the north began o be felt, and the river again rose to the danger line on the 16th. The water began encroaching on low places in the railroad track between Gregory and Canton, Mo., by the evening of the 18th. Heavy rains throughout southern Iowa, causing a flood in the Des Moines River, also swelled the Mississippi rapidly and by the evening of the 24th trains for St. Louis were abandoned. Alexandria and Gregory, Mo., and the river bottoms in Clark County were flooded back to the hills, making the river from 4 to 6 miles wide. On the 25th the flood from the upper Des Moines reached the mouth of the river, cutting across the land and carrying away part of the railway track north of Alexandria. On the morning of the 27th the Hunt Levee broke, 5½ miles below Warsaw, and a large area of growing wheat was flooded, the first material damage done on the Illinois side. The crest of the flood (18.5 feet) reached Keokuk on the evening of the 27th. The entire lumber district of Keokuk was then covered by from 2 to 4 feet of water. At the end of the month the river, though still at a dangerous stage, was falling rapidly, with a prospect of the flood ending without further damage. At the commencement of the month the Illinois River was still above the danger line, but was falling steadily and the fall continued throughout the month. On April 12 the river was below the danger line at Peoria for the first time in thirty-two days.

Farmers along the Mississippi between Keokuk and St. Louis commenced to remove stock and other movable property from the lowlands at the beginning of the month and preparations were made to protect the levees. On the 1st a levee in the western portion of Hannibal, built to confine the waters of Bear Creek, was overflowed and the Missouri, Kansas and Texas Railroad levee, in the same neighborhood, was carried away. On the 2d the Fox River overflowed the Missouri bottoms opposite Warsaw, and much farm land was submerged. The levee at Fall Creek, a few miles south of Quincy, was broken and several farms were submerged. Opposite Alton, Ill., the water was commencing to encroach upon the lowlands, and by the 5th much wheat land was covered and the crops ruined. Near St. Louis on the 10th the water poured into West Venice, Ill., which is situated

on low land, and the inhabitants used boats in the streets to remove their effects. The lowlands back of East St. Louis were overflowed, the water coming through Cahokia Creek. The town proper is amply protected by railroad embankments up to a stage of about 34 feet. Portions of East Carondelet, Ill., were also flooded.

The second rise of the month in the Mississippi commenced on the 13th and was much more decided than the previous one. It continued until the 28th at Burlington, and was still in progress from Louisiana southward to St. Louis at the close of the month. During this rise the water rose from 3.5 to 6.5 feet above the danger lines at all points from Louisiana northward to Keokuk, and much damage was done, mainly through the flooding of farm lands. The river became 8 miles wide at Quincy and about the same at Burlington, and railroad travel along the west bank was entirely suspended for a number of days. By April 24 about 200 square miles of land were submerged near Hannibal. The Indian Grave levee at Quincy remained intact on account of the continued and persistent work expended upon it. As a rule, the larger cities suffered comparatively little damage, but the smaller towns of Alexandria, Canton, La Grange, and Gregory were completely inundated. On the overflowed farm lands the losses were minimized through the farmers taking advantage of the timely warnings, which enabled them to remove their effects to places of safety. The crops were, of course, ruined, but even in this respect the losses were comparatively small, as the wheat crop was in very poor condition, and the alluvial deposits brought down by the waters will perhaps fully compensate for the loss of this year's small crop. What is most desired now is a sufficient recession of the waters to allow corn to be planted on the overflowed lands; this now seems probable.

Between St. Louis and Cairo the river continued at a high stage the entire month, but at no time was the danger line reached at points above Cairo. From Cairo to Memphis the river was falling most of the month, but, owing to the very slow rate of fall, flood conditions continued throughout April. The levees at Price's Landing, Mo., broke on the night of the 3d, but were repaired during the 4th. From Cairo to Island No. 25, about 155 miles below, both banks of the river have been largely submerged, and, even where the levees held, backwater from the breaks has covered a considerable portion of the counties lying along the river. The overflows this spring have not been as great as in former floods, owing to the fact that levees have been built and strengthened since the last great flood.

The crevasses in the Mississippi levees between Cairo and Memphis are given in the following table:

Place.	Date of break.	Date of measurement.	Width in feet (total).	Estimated depth in feet.
Caruthersville, Mo.	March 18	April 21	3,050	6
Tyler Landing, Mo. (2 breaks)	March 22	April 20	2,630	3
Between Foot of Bullerton and Oceola, Ark. (8 breaks)	Mar. 16-22	April 20	4,060	2½
Nodena, Ark., to opposite Fulton, Tenn. (11 breaks).	Mar. 13-14	April 19	3,585	2

Most of the water passing through these crevasses enters the St. Francis River.

On April 1 the river was 10.6 feet above danger line at Cairo, 10.0 feet at New Madrid, 3.4 feet at Memphis, and 7.1 feet at Helena. The decrease in the stage of water at the same points, for the month, was as follows: At Cairo, 13.3 feet; at New Madrid, 9.0 feet; at Memphis, 2.5 feet; at Helena, 5.4 feet; and at Marked Tree on the St. Francis, 4.8 feet. From Cairo to New Madrid the river fell from 0.4 to 0.5 foot daily during the first week, when a slight rise set in, which was felt as far south as Memphis, where a rise of 0.1 foot occurred on the 15th. Except this temporary swell, which lasted only a day or two at any point, the water from Memphis north continued to fall gradually all through the month, the fall during the last week, however, being more rapid. The fall at Memphis was very slow up to the 22d, when the stage had been lowered but 1 foot, and for the following nine days it amounted to 1.5 foot. At Helena the flood reached its maximum on the 4th with a 51.8 foot stage, 7.8 feet above danger line and 3.8 above the highest known stage. A break occurred in the Mississippi State levee on the 4th, which caused the river at Helena to fall about 3.5 feet. The break, which is opposite the mouth of the St. Francis River and on the farm of Mr. F. M. Norfleet, is over 2,000 feet wide, and resulted in the overflow of a large territory from Tunica County south, which embraces some of the most productive cotton lands in this section. On the St. Francis River the maximum stage of 53.4 feet was reached on April 4. At the close of the month the stage of water at points between Cairo and Memphis was slightly above the danger line. The following are the number of days the river has been above danger line at the points named: Cairo, 59; New Madrid, 63; Memphis, 53; and Helena, 50. On April 30 a very narrow strip of land could be seen opposite Memphis for the first time since March 9, a period of fifty-two days.

A crevasse was formed on the Mississippi side of the river on April 21 at Promise Land levee in Issaquena County and another at Biggs levee, about 5 miles below Vicksburg on the Louisiana side, on the 13th. Much valuable farm land was overflowed on both sides of the river and considerable stock and other property lost. The outlook at the end of the month is more favorable, owing to falling water, and efforts will be made shortly to close the crevasses. Some are planting as the water recedes and repairs to the railroad between Memphis and Vicksburg are being made as fast as the water declines. This flood was the most disastrous ever experienced in the Mississippi Delta.

There was a continuous rise in the Mississippi below Vicksburg during the month, all previous flood stages being passed at all points from Vicksburg to the Gulf. The total rise at Natchez amounted to 3 feet, at Red River Landing to 6 feet, at Bayou Sara to 5.5 feet, at Donaldsonville to nearly 4 feet, and at New Orleans to 2 feet. A nearly stationary stage was maintained at Natchez during the last half of the month on account of the Biggs crevasse that occurred on the 16th and overflowed Madison and portions of Tensas and Concordia parishes, thus relieving the stages between Vicksburg and the mouth of the Red. The Glasscock crevasse, 20 miles below Natchez, that occurred on the 19th, aided in maintaining the nearly stationary river above the mouth of the Red.

The bulk of the water from the Biggs-Reid crevasses moved down the Tensas River, Bayou Macon, and the Black River, overflowing the lowlands all along those streams, and the backwater affecting the lowlands of Franklin, Catahoula, and Avoyelles parishes by the close of the month. The swamp lands and hollows of those northeastern parishes hold an immense amount of water, which accounts for the fact that the upper Atchafalaya and extreme lower Red rivers were not materially affected by crevasse water at the close of the month.

The following breaks were caused by the flood: Davis Island on the 12th; Babins Place, one mile below Lafourche Crossing, on the Bayou Lafourche, on the 16th; Reid, 1½ miles below Biggs, on the 19th; Glasscock, 20 miles below Natchez, on the 19th; Coons Landing, on the Tensas front, on the 20th; Melrose, 49 miles below New Orleans (since closed), on the 26th; Guesnard, 400 yards below Melrose (since closed), on the 26th; Cocos, on Bayou des Glaizes (since closed), on the 29th; Home Place, about 58 miles below New Orleans (since closed), on the 29th. The situation is decidedly critical at numerous points below the mouth of the Red at the close of the month, weak places developing daily, and work being constant in strengthening the weak spots and in raising the levees.

At Fulton and above, decreasing stages, for the most part, characterized the Red River. Last month's rains gave a rising stream at Shreveport until the 14th, and at Alexandria until the 20th. The crest of this wave reached 24.1 feet at Shreveport, the highest since August, 1895. Great activity prevailed in river business, it being the first month since last spring during which navigation could be carried on without interruption. The anxiety that was felt last month extended into this, but was quickly allayed by the encouraging reports from the upper river during the first week. The Ouachita declined slowly at Monroe after the 10th, the range for the month being about 2 feet. The upper Ouachita also declined, excepting a rise of about 6 feet from the 14th to 17th at Camden.

Missouri River and branches. (Reported by L. A. Welsh, Omaha, Nebr., and P. Connor, Kansas City, Mo.)—The ice in the Missouri River at Williston passed out on the night of March 31, and the river is reported to have continued clear of ice throughout the month of April, and at the close of the month it was in about its normal condition. The ice gorge above Bismarck broke on the 11th, and the force of the rising water broke up the ice at Bismarck and caused it to run out, no damage resulting from its going out. The ice continued running on the 12th and 13th and the river remained almost stationary. On the 14th the river was reported clear of ice and stationary and all danger of further floods considered past. At Pierre the river was clear of ice until about 9 p. m. of the 7th, when ice began running, and the heaviest run of the season occurred during the ensuing twenty-four hours; floating ice in smaller quantity appeared on the 9th, 10th, and 13th. The ice did not gorge and there was no damage from the flood, except the erosion of banks in some localities. The channel at Crow Creek shifted from the east to the west side of the river, and the channel in front of Pierre also changed slightly, moving from the west side nearer to the center of the river.

On the 10th the river bottoms from Yankton to Sioux City were overflowed with water. No material damage was caused by the high water in that territory, owing to the fact that every possible precaution had been taken to guard against loss. The highest stage of water during the spring was reached at Sioux City on the afternoon of the 11th; the river was bank full and a rise of a very few inches more would have caused great loss to jobbers on the river front, but the river became stationary in the late afternoon and began falling slowly during the night, and all danger of further flood was past at that point.

At Omaha the river rose slowly and steadily from the 1st of the month to the 6th, reaching a stage about three feet below danger line; it remained stationary during the 7th and began to fall slowly on the 8th. It again rose rapidly on the 11th and continued to rise until 6 p. m. on the 15th, when a stage of 17.2 feet was recorded, being 0.8

foot below the danger line. During the night of the 15th the river began falling and continued to fall slowly the remainder of the month. The amount of damage by high water in the vicinity of Omaha was very slight. The greatest damage sustained was by the Arctic and the Swift Ice Companies, whose ice houses are located on the river bottoms in the northern portion of the city.

On the 15th, at St. Joseph, the Missouri was reported to be higher than at any time since 1881, and some damage to railroad property was reported. The Rock Island tracks, opposite Leavenworth, Kans., were reported to be under water on the 15th, but little damage resulted, except delay in traffic and the necessity of sending the trains of that road and the Chicago and Great Western over the Burlington tracks.

At the close of the month the river was below danger line at all points above Kansas City, and all danger of floods in that portion of the river was considered past.

The Missouri, at Kansas City, at the beginning of the month was higher than the average for that time, but 5.4 feet below the danger line. It rose steadily, inundating on the 8th from twenty to thirty shanties erected by squatters on neutral ground in the packing house district at a stage of 20.4 feet, and about eight families located on accretions in the east bottoms. It crossed the danger line on the morning of the 15th, rendering sewers in the west bottoms unserviceable by backwater and causing the packing houses to use pumps. The swift current was also doing considerable damage by cutting banks.

On the 19th the river reached its highest, 22.8 feet, inundating a great portion of Harlem and causing many families to move out. Water was seeping into cellars of wholesale houses in the west bottoms; sewers were plugged in many places to prevent overflow and pumps were also used. Great anxiety was felt, for a greater rise meant not only inconvenience, but a movement of stock from cellars and the shutting down of business in several establishments. From the 19th the water fell, reaching 20.1 feet on the 24th and bringing much relief.

On the latter date, however, a second rise began, chiefly due to the Kaw. Previously the Kaw was well within its banks, but, owing to excessive rains in northern Kansas, where all its tributaries are located, it rose between 4 and 5 feet by the 27th; it carried immense quantities of débris consisting of portions of outhouses, fences, logs, animals, etc. The strong current cut through the Missouri to the Harlem bank and caused even higher water in Harlem than that of the 19th, although the gauge reading at Kansas City was 0.2 lower. Water leaked into a number of cellars in the west bottoms again and continuous pumping again became necessary. It drove from their homes about fifty squatters on the Kansas side, near the mouth of the Kaw. The water backed up some of the sewers in Armourdale and overflowed on the streets. Catch-basins and manholes were plugged with rock and cement to prevent overflow. A large force of men was put to work strengthening and otherwise caring for the Kansas City, Wyndotte and Northwestern Railway bridge which spans the Kaw near its mouth. A tremendous jam, composed of débris, was formed at the bridge and made necessary the removal of part of the trestlework to make an outlet. The western span of the bridge was sprung about 1 foot out of line and the rails twisted in several places. At this time all other railroads were intact at this place, but train service was much interfered with by floods at Leavenworth.

There was quite a rapid fall in the Kaw from the 27th to the close of the month, and a slow but steady fall in the Missouri, which still stood half a foot above danger line on the last day. The Suburban Belt and Santa Fe roads had large forces at work the greater part of the month, riprapping and otherwise protecting the river bank, their lines being close to the river. Farm lands were flooded for 15 miles below Kansas City.

The lower Missouri rose steadily during the first ten days of the month, but below the mouth of the Osage River not materially until the 9th, when the Osage and Gasconade discharges caused a rise of nearly 2 feet at Hermann. This rise in the Missouri checked the fall in the Mississippi, and, as a result, a second rise commenced south of the mouth of the Missouri on the 8th, lasting until the 11th. During the last twenty days of the month the river varied within narrow limits, closing with stages near the danger lines from Boonville westward, but falling steadily.

Arkansas River. (Reported by J. J. O'Donnell, Fort Smith, Ark., and F. H. Clarke, Little Rock, Ark.)—A good, navigable stage prevailed during the month in the upper Arkansas. The river remained about stationary to the 6th, and then rose steadily to 12.8 feet on the 10th; it then fell to 4.2 on the 25th, when, at 4.30 p. m., the rise caused by the heavy rains of the 23d and 24th in the Canadian River Valley began to appear. At 7 p. m. the water was rising 3 feet per hour and the gauge reading was 15.3 at 8 a. m. on the 26th. The river fell to 11.8 on the 29th, when the heavy rains and cloud-burst reported in the Cottonwood and Cimarron valleys in the vicinity and to the west of Guthrie on the 26th and 27th caused a further rise to a stage of 18.2 at noon on the 30th; the river was again falling at 3 p. m. The average stage of 8.7 feet is the highest for April since 1892.

A good boating stage was maintained during the month of April from Fort Smith to the mouth. No damaging floods occurred, although back water from the Mississippi overflowed for a short distance above the mouth. The river did not even approach the danger line at any station; it rose 9.0 feet at Dardanelle on the 27th and 5.2 feet at Little Rock on the next day. This marked rise was caused by heavy rains that fell in the Indian Territory from the 24th to the 28th.

Rivers on the Pacific Coast. (Reported by W. H. Hammon, San Francisco, Cal.; J. A. Barwick, Sacramento, Cal.; and B. S. Pague, Portland, Oreg.)—The rivers of the Sacramento and San Joaquin valleys did not reach any high stages during the month of April. The month was unusually dry. The Sacramento River at Sacramento has ranged between 22.8 feet and 19.9 feet. The Tule basins of Sutter, Yolo, and Solano counties still contain vast bodies of water, but as fast as the water recedes all lands that are tillable are rapidly being planted to late potatoes, beans, and buckwheat. The river has been as usual for April, that is, very uniform in its stages, owing to the steady melting of snow in the mountains.

During the month the increased temperatures prevailing over Washington, Oregon, and Idaho, especially from the 13th to the 18th, caused the Columbia, Snake, and tributary rivers to rise from melting snow. The small streams, which in September are almost dry, rose to a higher point than has been known for a number of years. The Powder River did considerable damage in the vicinity of Baker City. Many miles of track of the Oregon Railway and Navigation Company were washed out and connection with the Union Pacific was broken off for four days. The Willamette River above the falls at Oregon City had a very slight rise. All rises were due directly to the melting of the snow in the lowlands and the foot hills. The rise in the Columbia caused the lower Willamette to back to a height of 18.4 feet on the 23d. At 15 feet the lower docks at Portland are flooded. Timely notice of the rise was given so that all goods, property, and offices were removed from the docks before the water reached them. There was no interference with navigation. Conditions point to a material rise in the Columbia and tributary rivers and consequent backwater in the Willamette at Portland during the next sixty days.

Heights of rivers above zeros of gauges, April, 1897.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Mississippi River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
St. Paul, Minn.	1,934	14	18.0	6	10.3	30	14.9	7.7
Reeds Landing, Minn.	1,864	12	12.3	8	8.1	30	10.3	4.2
La Crosse, Wis.	1,799	10	13.7	10	10.0	30	11.9	3.7
North McGregor, Iowa	1,739	18	17.6	13,14	11.1	1	14.9	6.5
Dubuque, Iowa	1,679	15	17.9	15	10.1	1	15.0	7.8
Leclaire, Iowa	1,589	10	11.9	17–18	6.5	1	9.8	5.4
Davenport, Iowa	1,573	15	15.1	18	9.0	1	12.7	6.1
Keokuk, Iowa	1,443	14	18.5	27	12.7	12	14.8	5.8
Hannibal, Mo	1,382	17	20.8	29	14.5	13–15	16.4	6.3
Grafton, Ill	1,284	23	22.6	6	18.8	1	20.8	3.8
St. Louis, Mo.	1,241	30	29.9	30	24.0	1	27.5	5.9
Chester, Ill.	1,170	30	26.8	12	20.5	1	24.2	6.3
Cairo, Ill	1,073	40	50.6	1	37.0	30	46.8	13.6
Memphis, Tenn	843	33	36.4	1	33.4	30	35.6	3.0
Helena, Ark	767	44	51.8	4	45.7	30	48.1	6.1
Arkansas City, Ark.	695	42	50.6	1	48.3	30	49.5	2.3
Greenville, Miss	595	40	45.4	1	42.7	30	44.2	2.7
Vicksburg, Miss	474	41	52.3	16	49.2	4–5	51.0	3.1
New Orleans, La	108	16	19.3	29	17.4	1	18.4	1.9
Arkansas River.								
Fort Smith, Ark.	345	22	17.4	30	4.2	24, 25	9.3	13.2
Dardanelle, Ark.	250	21	13.7	28	4.2	25	8.5	9.5
Little Rock, Ark.	170	23	14.9	29	6.9	26	10.6	8.0
White River.								
Newport, Ark	150	21	26.4	13	16.7	27	22.1	9.7
Illinois River.								
Peoria, Ill.	135	14	17.3	1	11.2	28	13.5	6.1
Missouri River.								
Bismarck, N. Dak.	1,201	14	22.2	6	5.8	27, 28, 30	10.7	16.4
Pierre, S. Dak.	1,006	14	12.1	13	6.4	30	7.8	5.7
Sioux City, Iowa	676	19	16.4	15	9.9	29, 30	12.9	6.5
Omaha, Nebr.	561	18	17.2	15	11.3	30	14.1	5.9
Kansas City, Mo.	280	21	22.8	19	14.6	1, 2	20.1	8.2
Boonville, Mo.	191	20	20.0	29	13.5	1	17.3	6.5
Hermann, Mo.	95	21	15.8	30	12.3	4	13.7	3.5
Ohio River.								
Pittsburg, Pa	966	22	13.5	11	4.0	26, 30	7.0	9.5
Davis Island Dam, Pa.	960	25	13.2	11	5.8	26	8.3	7.4
Wheeling, W. Va.	875	36	20.7	11	7.0	27	11.0	13.7
Marietta, Ohio	795	25	21.2	12	7.9	28	12.3	13.3
Parkersburg, W. Va.	785	35	21.8	12	8.0	28	12.9	13.8
Point Pleasant, W. Va.	703	36	26.0	13	7.9	30	15.5	18.1
Catlettsburg, Ky	651	50	31.3	12, 13	10.8	30	21.0	20.5
Portsmouth, Ohio	612	50	32.3	13	12.3	30	22.2	20.0
Cincinnati, Ohio.	499	45	36.2	15	15.1	30	26.3	21.1
Louisville, Ky.	367	24	13.5	16	7.0	30	10.4	6.5
Evansville, Ind	184	30	33.5	17, 18	15.3	30	27.6	18.2
Mount Vernon, Ind.	148	35	34.6	18	16.3	30	29.6	18.3
Paducah, Ky.	47	40	47.0	1	24.3	30	38.3	22.7
Alleghany River.								
Warren, Pa	177	7	4.8	15	1.8	5, 7	2.7	3.0
Oil City, Pa	123	13	5.2	15	2.5	25	3.5	2.7
Parkers Landing, Pa.	73	20	5.0	10	2.5	6–7	3.9	2.5
Freeport, Pa.	26	20	12.8	10	4.5	25	7.0	8.3
Conemaugh River.								
Johnstown, Pa.	64	7	5.0	9	1.6	25, 29, 30	2.6	3.4
Red Bank Creek.								
Brookville, Pa.	35	8	2.9	10	0.2	28–30	1.3	2.7
Beaver River.								
Ellwood Junction, Pa.	10	14	4.8	10	0.8	4–5	1.9	4.0

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Big Sandy River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Louisa, Ky	26	20	25.5	6	4.2	5	9.7	21.3
Cumberland River.								
Burnside, Ky	434	50	58.1	5	4.3	25	12.2	53.8
Carthage, Tenn	257	30	42.5	7	5.4	25	17.5	37.1
Nashville, Tenn	175	40	42.2	9,10	9.1	25	22.9	33.1
Great Kanawha River.								
Charleston, W. Va	61	30	9.1	11	4.3	26,27	6.2	4.8
New River.								
Radford, Va	153	14	2.7	6	0.7	27,30	1.3	2.0
Hinton, W. Va	95	14	4.7	7,11	2.1	30	3.0	2.6
Licking River.								
Falmouth, Ky	30	25	17.6	9	2.7	3,4	5.4	14.9
Miami River.								
Dayton, Ohio	69	18	7.1	10	2.0	{3,4,22,} {25,28,29}	3.1	5.1
Monongahela River.								
Weston, W. Va	161	18	3.6	9	−0.3	30	0.5	3.9
Fairmont, W. Va	119	25	8.1	10	0.9	30	2.8	7.2
Morgantown, W. Va	95	20	13.6	10	7.4	29,30	8.8	6.2
Greensboro, Pa	81	18	13.0	10	7.6	27-30	9.0	5.4
Lock No. 4, Pa	40	28	17.0	10	6.9	30	9.6	10.1
Cheat River.								
Rowlesburg, W. Va	36	14	6.0	10	1.6	28,29	3.2	4.4
Youghiogheny River.								
Confluence, Pa	59	10	6.9	10	1.4	24	2.9	5.5
West Newton, Pa	15	23	7.6	10	1.1	30	2.6	6.5
Tennessee River.								
Knoxville, Tenn	614	29	.....	.....	.....	.....	.....	.....
Rockwood, Tenn	519	30	.....	.....	.....	.....	.....	.....
Chattanooga, Tenn	430	33	30.8	6	5.8	30	12.4	25.0
Bridgeport, Ala	390	24	22.8	7	4.2	28	9.9	18.6
Florence, Ala	220	16	18.3	10	4.2	29	10.4	14.1
Johnsonville, Tenn	94	21	40.1	1	7.2	30	23.1	32.9
Wabash River.								
Terre Haute, Ind	165	16	11.2	14	4.5	23	7.4	6.7
Mt. Carmel, Ill	50	15	19.5	17	8.0	25	14.1	11.5
Red River								
Arthur City, Tex	688	27	9.7	1	3.5	26	6.5	6.2
Fulton, Ark	565	28	25.9	1,2	6.5	30	15.4	19.4
Shreveport, La	449	29	24.1	13,14	14.5	30	21.2	9.6
Alexandria, La	139	33	26.3	15-16	21.5	30	24.5	4.8
Atchafalaya River.								
Melville, La	100*	31	35.7	29,30	33.5	1	34.8	2.2
Ouachita River.								
Camden, Ark	340	39	24.8	18	8.1	30	17.5	16.7
Monroe, La	100	40	37.9	9-12	35.6	30	37.0	2.3
Yazoo River.								
Yazoo City, Miss	80	25	31.5	27,30	26.4	1	29.6	5.1
Tombigbee River.								
Columbus, Miss	285	33	11.7	10	0.2	24,25	5.4	11.5
Demopolis, Ala	155	35	52.4	1	5.9	29	27.7	46.5
Black Warrior River.								
Cordova, Ala	155	20	16.0	10	3.4	29	6.2	12.6
Tuscaloosa, Ala	90	38	29.4	11	5.1	29	16.0	24.3

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Alabama River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Montgomery, Ala	265	35	22.3	11	4.8	29	11.1	17.5
Selma, Ala	212	35	25.0	12	7.0	28-30	14.1	18.0
Coosa River.								
Rome, Ga	225	30	18.9	6	3.2	30	7.1	15.7
Wilsonville, Ala	66	15	10.0	10	3.4	30	5.6	6.6
Tallapoosa River.								
Sturdevant, Ala	69	15	3.8	10	1.8	28,29	2.6	2.0
Savannah River.								
Augusta, Ga	130	32	28.5	6	8.5	29,30	13.1	20.0
Edisto River.								
Edisto, S. C	75	6	5.3	11	3.3	29,30	4.6	2.0
Congaree River.								
Columbia, S. C	37	15	15.5	6	0.9	22	3.6	14.6
Santee River.								
St. Stephens, S. C	50	12	11.5	14	6.8	30	8.6	4.7
Wateree River.								
Camden, S. C	45	24	28.6	7	6.3	28	10.7	22.3
Black River.								
Kingstree, S. C	60	12	7.9	17	4.9	30	6.7	3.0
Pedee River.								
Cheraw, S. C	145	27	30.4	7	3.4	27,28	9.3	27.0
Linch Creek.								
Effingham, S. C	35	12	12.3	13	4.3	29	7.8	8.0
Lumber River.								
Fair Bluff, N. C	10	6	5.3	17,18	2.9	30	4.5	2.4
Waccamaw River.								
Conway, S. C	40	7	4.4	1	1.6	29,30	3.0	2.8
Cape Fear River.								
Fayetteville, N. C	100	38	28.3	7	4.4	30	11.8	23.9
James River.								
Lynchburg, Va	257	18	2.5	7,9	1.0	26,29,30	1.6	1.5
Richmond, Va	110	12	1.6	9	0.1	29,30	0.6	1.5
Potomac River.								
Harpers Ferry, W. Va	170	16	5.0	11	1.5	30	2.6	3.5
Susquehanna River.								
Wilkesbarre, Pa	178	14	.....	.....	.....	.....	.....	.....
Harrisburg, Pa	70	17	9.5	12	3.2	30	5.2	6.3
W. Br. of Susquehanna.								
Lock Haven, Pa	63	10	4.0	10	1.3	5-7,28-30	2.2	2.7
Williamsport, Pa	35	20	8.8	11	2.7	30	4.8	6.1
Juniata River.								
Huntingdon, Pa	80	24	6.7	10	3.8	30	4.5	2.9
Sacramento River.								
Redbluff, Cal	241	23	8.1	17-19	5.8	7	7.3	2.3
Sacramento, Cal	70	28	22.8	22	19.9	1	21.1	2.9
Willamette River.								
Eugene, Oreg	149	10	.....	.....	.....	.....	.....	.....
Albany, Oreg	99	20	.....	.....	.....	.....	.....	.....
Salem, Oreg	69	20	.....	.....	.....	.....	.....	.....
Portland, Oreg	10	15	18.4	23	7.6	5	12.4	10.8

* Distance to the Gulf of Mexico. † Mean for 29 days. ‡ Frozen, 1-4.

SPECIAL CONTRIBUTIONS.

RECENT PUBLICATIONS.

By HERMAN W. SMITH, Librarian, Weather Bureau.

The Chief of the Weather Bureau has directed that there be published regularly in the REVIEW a list of recent publications received by the Library. In the following list the publications, not only of the Department of Agriculture, but of the Government in general, are omitted, as their titles are already accessible to the public through the publications issued by the Superintendent of Public Documents. The present list includes only such other works as seem to bear directly on meteorology and other matters connected with the work of the Weather Bureau. It is to be understood that those who wish to consult these works must do so in Washington, where every convenience for study is afforded.

Austria-Hungary.—Jahrbücher der Königl. Ung. Central-Anstalt für Meteorologie und Erdmagnetismus. Officielle Publication, XXIII Band, Jahrg. 1893. Budapest, 1895. 4to. xix, 169 pp.

Belgium.—Congrès de l'Atmosphère. Organisé sous les auspices de la Société royale de Géographie d'Anvers, 1894. Compte Rendu. Anvers, 1895. 8vo. 272 pp.

Brazil.—Relatorio annual do Instituto Agronomico do estado de São Paulo (Brazil) em Campinas. Vol. VII-VIII, 1894-1895. S. Paulo, 1896. 4to.

British Empire.

Canada.—Twenty-second Annual Report of the Ontario Agricultural College and Experimental Farm. Eighteenth Annual Report of the Agricultural and Experimental Union, 1896. Toronto, 1897. 8vo. xxiv, 309 pp.

England.—Report of the Kew Observatory Committee of the Royal Society for the year ending December 31, 1896. London, 1897. 8vo. 34 pp.

Report of the Meteorological Council of the Royal Society for the year ending 31st of March, 1896. London, 1896. 8vo. 129 pp. 1 map, 10 by 15.

Memoranda of the Origin, Plan, and Results of the Field and Other Experiments Conducted on the Farm and in the Laboratory of Sir John Bennet Lawes, at Rothamsted, Herts. London, 1896. 8vo. 105 pp.

Transactions and Fifth Annual Report of the Council of the Liverpool Geographical Society for the year ending December 31, 1896. Liverpool, 1897. 8vo. 125 pp. 1 plate and 1 chart.

Denmark.—Mémoires de l'Académie Royale des Sciences et des Lettres de Danemark, Copenhague. En Mathematisk Undersogelse af, hvorvidt Vaedsker og deres Dampe kunne have en faelles Tilstandsligning, baseret paa en kortfattet Fremstilling af Varmetheoriens Hovedsaltninger. Ved F. Buchwaldt. Kjobenhavn, 1896. 4to. pp. Del 110-172.

France.—Météorologie Agricole, par F. Houdaille. Paris, n. d. 16mo. 204 pp.

Traité Pratique de Prévision du Temps, par J. R. Plumandon. Paris, 1895. 12mo. 86 pp. 19 charts and 11 tables.

Germany.—Forschungen auf dem Gebiete der Agrikulturphysik. 19 Band, 4 u. 5 Heft. Dr. E. Wollny. Heidelberg, 1896. 8vo. ix, 209 pp. 1 plate.

Russia.—Beobachtungen des Tiflisser Observatoriums im Jahre 1895. (1895.) Tiflis, 1897. 4to. xxix, 198 pp.

United States of America.

Bowker, R. R. United States Government Publications, July 1, 1890–June 30, 1895. Compiled, under the editorial direction of R. R. Bowker, by J. H. Hickox. (Reprint of Appendix of American Catalogue, 1890–1895.) New York, 1896. 10 by 11. 60 pp.

United States Navy Department, Hydrographic Office. Illustrated Cloud Forms for the Guidance of Observers in the Classification of Clouds. C. D. Sigsbee, Captain United States Navy, Hydrographer. Washington, 1897. 5¼ by 9¼. 16 plates.

District of Columbia.—Report of the Health Officer of the District of Columbia for the year 1896. Washington, D. C., 1896. 8vo. 277 pp. 6 charts, 30 by 30.

Michigan.—Twenty-second Annual Report of the Secretary of the State Board of Health of the State of Michigan for the fiscal year ending June 30, 1894. Lansing, 1896. 8vo. cciv, 526 pp.

Proceedings and Addresses of the Third Annual Conference of the Health Officers in Michigan, held at the State Laboratory of Hygiene, State University, Ann Arbor, Mich., July 16–17, 1896. Lansing, 1896. 8vo. 139 pp.

New Jersey.—Seventh Annual Report of the Board of Directors of the New Jersey Weather Service for the year 1896. Trenton, 1897. 8vo. 240 pp. 4 maps, 10 by 14.

THE EARLY USE OF WIRE IN KITE FLYING.

By S. P. FERGUSSON (dated Blue Hill Observatory, April 9, 1897).

After the account of the high kite ascension at Blue Hill on October 8, 1896, was published, I received a letter from Mr. Thomas H. Butler, of Providence, R. I., giving an account of some experiments in kite flying made by him and his friends in England about forty years ago. Mr. Butler stated that iron wire was employed as line, and sometimes 2 or 3 miles were let out and taken up by the kites. Strong electric shocks were experienced by those holding the line.

As Archibald, of England, had received credit for being the first, in 1883 and 1884, at the suggestion of Sir William Thomson, to make use of steel wire for kite line, Mr. Butler's letter was interesting, especially in regard to the early use of wire, and to the altitudes reached. I wrote him asking for further information, and he corresponded with some friends in Bradford, England, who sent him two clippings from the *Bradford Observer Budget*, and a letter, which Mr. Butler has kindly sent me. I copy Mr. Butler's letter (1) and the newspaper extracts (2 and 3) below, as also (4) Mr. Pyrah's letter of January 30, and append a few additional remarks (5):

(1) *Letter from Mr. Thomas H. Butler, of Providence, R. I., to S. P. Fergusson.*—Please find enclosed a little information toward proving my previous statement regarding the early use of wire as a kite line. * * * For a five-foot tall kite, we used small cane or brier for the bow with a strong lath for the perpendicular or backbone as I will call it, and good twine. But for a giant kite such as you would require the bow wants to be made of lancewood such as used for archery purposes, and the backbone of strong but lighter wood, and in the place of twine use thick, strong wire and you could make a pretty light frame big enough to lift a man. It is a pleasure to see this style of kite go up. When she strikes the wind as soon as she is let loose she is as graceful and pliable as a bird. I believe a giant kite constructed after the above design would reach a higher altitude than has been reached yet with a great deal less expense and trouble. * * *

(2) *Extract from Bradford Observer Budget of February*, 1897.—In reply to your correspondent who writes for information in respect to flying kites with wire in Bierly Lane, Bradford, I beg to inform you that I remember that Mr. Joshua Law had a wire mill close to Bierly Lane, and he had at that time three men in his employ, namely, George Walker, Solomon Shires, and Christopher Firth, and I have seen these men fly kites with two and a half miles of wire more than fifty years ago; and if a piece of string was tied to the end of the wire nearest the hand, on touching the wire quite a strong electric shock was felt. The Mr. Butler who writes to you from Olneyville, U. S. A., I have known from childhood, but he being quite twenty years my junior may not remember the above. I am, etc., WM. WEBSTER.

Black Swan Hotel, Boroughbridge, February 4, 1897.

(3) *Extract from the Bedford Observer Budget of February*, 1897.—I saw the letter of the 4th of February, 1897, from Mr. Webster, Black Swan Hotel, Boroughbridge, and it was quite correct. I have known him ever since he was a boy, and all his family, too. Kite flying with wire was practised at Dudley Hill by workmen from Mr. Joshua Law's wire works 55 years ago, and the kites were sent up with 2½ miles of wire attached to them. In 1842 and 1843 I saw kites sent up and drawn in again, and the electric shocks from them were something terrific. I have seen sparks of fire when the wire was touched with a knife blade, and men and boys severely shaken and some fall to the ground. I have a friend at Low Moor, 60 years of age, who informs me that he used to fly kites with wire 50 years ago at Mr. Dan. Bateman's wire works, and he has seen men fly kites 4 feet long and 2 feet 8 inches wide, with tails attached 20 yards long, and a lantern with a big candle at the end, so that you could imagine the kite was a little star. He also assures me that kite flying was practised 80 years back at Mr. Bateman's works. When Robert Stephenson, the great engineer, was a boy, his father bought him a donkey to ride to school, and while pursuing his journey he used to fly kites with copper wire a mile long; that was 60 years ago. (See his life, page 126.) For fun he used to touch the head of the donkey with the wire, and of course the donkey knew about it. Kite flying has been practised in England with iron wire, steel wire, and copper wire. Hoping this will satisfy our American friends who think that kite flying with wire is of recent introduction, I am, etc., JOHN PYRAH.

8 Heeles street, Tong street, near Bradford.

(4) *Letter of Mr. Pyrah addressed to Mr. Butler.*—Having seen your correspondence on kite flying with wire, I will give you facts which I witnessed fifty-six years ago. The works of Mr. Law's, wire drawer and card manufacturer, were at Goose Hill, now called Rooley Lane, near Bradford, in Yorkshire, and their workmen tried kite flying for a whole summer by the White Heart publick house in my presence in 1842, fifty-six years ago. I was then fourteen years old, and lived at the place. I was sadly shaken myself when I was asked to touch the wire, and a great many were laid on their backs by the electric currents; at last they were ordered to give over before some one was killed. I saw it strike fire sparks when touched with a penknife or a button. This statement could be verified by many. I am rather surprised to hear that scientific men such as you name should not have known and published this before 1884. (Dated Bradford, January 30, 1897.)

(5) *Remarks by S. P. Fergusson.*—The kite described by Mr. Butler is very simple, consisting of a rather stiff upright stick, over the top end of which a flexible stick or cane is bent in the form of a bow. Cords from the ends of the bow extend to the lower end of the upright, and the covering is secured to the bow and to these cords. The bridle is attached at two points on the upright near the middle of the kite. The tail appears to be of cord, to which are attached short pieces of cloth or paper. Archibald's kites differed from this pattern in that they were diamond shaped, having no bow at the top, and in the use of a cone tail. The wire used by Mr. Butler and his friends was ordinary iron wire, about the diameter of a large pin.

Mr. Rotch has found in the English Mechanic of September 8, 1876, a letter from A. Willan, describing some electrical experiments with kites, from which the following is quoted:

I have always flown my electric kites simply with this iron wire (the best Swedish), any length of which can be obtained at places where the combs for wool-carding engines are made. * * * The wire I use is No. 23, B. W. G., but with a light wind a thinner size might with advantage be used. I have it wrapped on a large wooden bobbin and fixed in a wooden frame, so that it winds up with a handle. Care must be taken to avoid "kinks," which invariably result in a breakage of the wire.

From the above it appears that the use of wire for kites is not new; with the long lines employed, considerable altitudes were probably reached.

[It should be noted that Espy and the Franklin Kite Club used wire for flying their kites about 1836 in Philadelphia. See under Notes by the Editor.]

CLOUD MEASUREMENTS AT BLUE HILL.

(By H. H. CLAYTON, dated February 28, 1897.)

At Mr. Rotch's request I send herewith an example of my method of calculating the heights of clouds from the positions of their shadows. The first method we used was by a formula similar to one given by Professor Abbe in describing Feussner's method (see page 322 of his Treatise on Meteorological Apparatus and Methods), and which reads as follows:

$$z_1 = b \sin (a_2 \pm 180° - a_3) \tan h_1 \operatorname{cosec} (a_1 - a_2)$$

In which z_1 is the height of the cloud above Blue Hill; b is the distance to the cloud shadow, as measured on a map of the surrounding region; a_1, a_2, and a_3 are the azimuths of the cloud, sun, and cloud shadow, respectively; h_1 is the observed angular altitude of the cloud.

This, however, was only a partial solution since it gave only the height above one station and no criterion for determining the accuracy. Hence it was soon abandoned and the following modification of the method was adopted. The formulæ are not essentially different from those of Ekholm and Hagstrom (see page 315 of the above-mentioned Treatise).

When a cloud shadow is seen in a favorable position the

azimuth and angular altitude, a_1 and h_1, of the cloud are immediately measured with a theodolite; then the azimuth and angular altitude of the sun, a_2 and h_2, are measured; these are to be corrected when necessary for the slight change in the position of the cloud and sun during the time elapsing between the first and second observations; then the azimuth, a_3, and distance, b, of the cloud shadow are measured, as seen on the ground when the first observation was taken. The distance is taken from a map, of which we have a number, detailed, accurate, and on a large scale for the region around Blue Hill.

A moment's consideration will show that the measurement of the azimuth and angular altitude of the sun from Blue Hill takes the place of an observation of the sun and cloud with a theodolite at the position of the cloud shadow. For if an observer were at that point and looked toward the cloud he would find it exactly in the direction of the sun, and since the rays of the sun are practically parallel, he would get the same angular altitude and azimuth as that measured by observing on the sun from Blue Hill. Hence, by making the measurements of a_2 and h_2 from Blue Hill alone, we get the same results as if we had observers looking at the cloud simultaneously from the two ends of a base line, and the formulæ for calculating the results are the well-known trigonometrical relations:

$$A_1 = a_1 - a_3; \qquad z_1 = b \sin A_2 \operatorname{cosec} A \tan h_1$$
$$A_2 = a_2 - a_3; \quad z_2 = c + z_1 = b \sin A_1 \operatorname{cosec} A \tan h_2$$
$$A = a_1 - a_2; \qquad z_m = \tfrac{1}{2}(z_1 + z_2 - c)$$

This formula gives the mean altitude of the cloud above Blue Hill (z_m) from the results calculated from the two ends of a base line drawn from the lower station or shadow to a point below the upper station; c is the difference in level between the stations, and must be read off from the map by means of the contour lines, if the country is not quite level. The relations of the angles to each other in the above formulæ, and the agreement of the calculated heights z_1 and $z_2 - c$, furnish criteria[1] for determining the accuracy of the observations and for preventing errors which might arise, for example, from taking the angular measurements on one cloud, while by mistake using the shadow of another.

The following table gives the results of measurements made on a cumulus cloud on May 19, 1896. The heights in the second to the fifth columns were determined parallactically by two observers with theodolites observing simultaneously at the ends of the base line. The mean of their four results is given in the sixth column. The height given in the seventh column was determined a few minutes later (at 8:51 a. m.) by means of cloud shadows; evidently the two methods give practically the same results.

	Theodolite method.				Mean.	Cloud shadow method.
Time	8h 27m	8h 28m	8h 29m	8h 30m	.....	8h 51m
Calculated height in meters	961	967	972	950	962	953

The base of the nearly uniform stratus or nimbus, measured by kites, is, I think, lower as a physical reality than the broken sheets of the same clouds, the only kinds which permit of measurement with theodolites.

Example illustrating the method of computation by the above formula.

Distance of shadow $b = 4{,}482$ meters; shadow below Blue Hill $c = 44$ meters.

Time,	2h 53m p. m.	log tan h_1	9.6236	Z_2	1,543 meters
Cloud.	S. cu.	log sin A_2	9.7230	c	44 meters
$A_1 = a_1 - a_3$	106.0°	log b	3.6515		
$A_2 = a_2 - a_3$	148.1°	log cosec A	0.1737	$Z_2 - c$	1,499 meters
$A = a_1 - a_2$	42.1°	log sin A_1	9.9828	Z_1	1,485 meters
h_1	22.8°	log tan h_2	9.3803	Diff.	14 meters
h_2	13.5°			Z_m	1,492 meters
		log Z_1	3.1718		
		log $Z_2 = Z_1 + c$	3.1883		

[1] See note by the Editor on "Cloud Heights."

THE MECHANICS AND EQUILIBRIUM OF KITES.*

A monograph prepared by C. F. Marvin, Professor of Meteorology, U. S. Weather Bureau, submitted with the approval of Prof. Willis L. Moore, Chief of Weather Bureau, in competition for the "Chanute Prize" offered by the Boston Aeronautical Society.

ANNOUNCEMENT OF PRIZE.

Octave Chanute, Esq., ex-president of the American Society of Civil Engineers, generously offers the prize herein described.

Under date of May 27, 1896, he writes to the Society as follows:

"I herewith enclose $100, and authorize the Boston Aeronautical Society to offer this sum as a special prize for the best monograph on the kite, giving a full theory of its mechanics and stability, with quantitative computations appended.

"This prize to be awarded by judges appointed by the Society. It may be withheld one year in case no sufficiently complete monograph is handed in.

"To explain the latter reservation, it may be suggested that the following points need consideration:

"1. The resolution of all the forces acting upon an ordinary kite with a tail; *i. e.*, the wind pressure upon its surface, its tail, and its string, and the weight (gravity) of these various parts. The resulting equilibrium, or the diving, spinning round, or glancing sideways, and how the forces act which restore the balance. State the position of the center of gravity, center of pressure, and best point of attachment for the string, with numerical example.

"2. Give the same elements for the tailless kite, distinguishing between the Malay, the Japanese or Chinese, the Bi-polar, the Hargrave, and the Fin (Boynton) kites. Indicate also what are the general principles upon which each group of the tailless kites depends for its stability.

"3. What effect is produced by changes in the point of attachment of the string, and what is the pull thereon with various positions and with various strengths of wind.

"4. What is the difference in effect between the kite string and the attraction of gravity on the mass of a soaring bird.

"Sincerely yours, O. CHANUTE."

Competitors for this prize are requested to have their essays typewritten, and to send them in on or before November 15, 1896.

Address Secretary of the Boston Aeronautical Society, P. O. Box 1197, Boston, Mass., U. S. A.

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I.—INTRODUCTION.

Since our purpose is to present in full a theory of the mechanics and stability of kites in general, it will be well at the outset to clearly define the essential and fundamental conception that we consider to be conveyed or suggested by the word kite. Furthermore, the behavior of kites, however diverse in character and detail, results from the action and reaction of a small number of well known natural forces. Some of the forces that we must consider act upon the kite itself, while others, in a wholy independent manner, act upon the string or line employed to restrain the kite. Very important limitations to the attainments of which kites are capable arise wholly in consequence of the action of forces upon the string. Under these circumstances it will be most logical, after defining the kite, to consider without regard to any particular or specialized form of kite, those general and fundamental principles of physics and mechanics that underlie the action of all kites and study that relation of forces which is essential

*The above monograph, by Professor Marvin, was awarded the "Chanute Prize" by the judges appointed by the Boston Aeronautical Society, which society has also submitted it for publication in the MONTHLY WEATHER REVIEW.

to their flight and stability. In these studies we shall be led, also, to develop separately the results of the action of the forces on the string.

In order, finally, to give due consideration to the points specified under items 1 to 4, inclusive, in the announcement of the Chanute prize, it will suffice to apply the general theory that we shall first present to the several individual cases, pointing out the particular application and developing any special features that may arise.

II.—DEFINITIONS AND AXIOMATIC STATEMENTS.

Kite.—Fundamentally a kite is a surface or series of surfaces, either flat or curved, which are provided with a restraining attachment having the nature of a string or line. The surfaces and line are arranged in such relations that when the kite, held in restraint by the line, is exposed to masses of air in motion, the surfaces are subjected to wind pressures which sustain the kite in mid-air, where it assumes a position of equilibrium.

Ideal and actual kites distinguished.—Occasion will arise in our study of the mechanics of the kite to consider the results that follow when various defects and imperfections, generally found in kites, are absent. It will be desirable, therefore, to clearly distinguish at all times between what we shall call the *perfect* or *ideal kite*, from which all defects and imperfections are wholly absent, and the *actual* or *material kite*, which is always unavoidably trammeled by greater or less defects and imperfections. If the kite is a surface against which it is designed the wind shall press, then the ideal kite is that surface; the actual kite is a material substance having thickness, weight, edges, possibly a tail, etc.

The string, or *kite line*, or simply *line*, as we shall generally call it, is a subordinate accessory to the kite, and is unessential in so far as the mechanics of the kite is concerned. The specific function of the line is to hold the kite in restraint, and while doing so to assume without opposition any direction essential to the kite's equilibrium. It is conceivable that all the phenomena incident to the stability of a kite can be exhibited without the use of a string, as, for example, by securing the kite to the top of a suitable pole or mast by means of a connector in the nature of a universal joint. The only object in presenting this thought is to emphasize the essential independence of the kite and the string, so far as the mechanics of the former is concerned.

The ideal kite string is a flexible, inextensible, mathematical line, which has unlimited strength and is without weight or thickness. The actual material kite line is, in general, sufficiently flexible, but its weight and thickness, and sometimes its roughness are objectionable, and its strength is limited.

Bridle.—The bridle is a subordinate, often not an essential accessory of the kite. Its purpose is to provide a point for the attachment of the restraining line to the kite, such that certain relations are permitted between the restraining forces acting in the line and the forces of the wind pressure and gravity acting upon the kite. The bridle may also be made to serve a secondary purpose, as follows: The resultant pull, due to all the forces acting upon the kite, is accumulated and transmitted to the line through the bridle. In addition, therefore, to serving its normal function, as stated above, the bridle may incidently be made to distribute the strains upon certain members of the framework of the kite in such a manner that they can safely sustain greater strains than might be the case without the bridle.

Pull, lift, drift, tension.—In referring to the strain upon the kite line which tends to tear it asunder we shall employ the words pull or tension, and when so used the words will be considered synonymous. *Lift* is the vertical and *drift* the horizontal component of the *pull*. We may logically deal with the pull, lift, and drift, not alone at the kite, but likewise at any point along the line. If at a given point the inclination of the kite line to the horizontal is the angle θ, and the tension is t, then the *lift* equals $t \sin \theta$, and the *drift* equals $t \cos \theta$.

Tail.—Some kites can not preserve their equilibrium without the assistance of a tail; with others it is unnecessary, although a tail may be applied to any kite. When present, the kite is subjected to the action of one more force than would otherwise be the case. This force is the resultant of the action of gravity and the wind upon the tail.

III.—GENERAL STATEMENT.

The flight of any conceivable kite and the motions it may execute—including, for example, the general case of a faulty and insubordinate member of a tandem, which, being held at a comparatively fixed point high up in the free air, can not end its erratic flight in a precipitate dash to the ground, but must go on and execute any orderly or disorderly movements the circumstances may demand, even if it be broken and distorted—all possible evolutions of such a kite or of any other, under any and all circumstances, find their full explanation in the application of the following general proposition of mechanics, the full demonstration of which is to be found in the ordinary text books:

Any system of forces acting upon a rigid body may always be reduced to a single resultant force, R_0, having a definite and determinate position and a resultant couple, Z_0, the forces of which act in a plane perpendicular to the force R_0. The force and couple can, together, produce exactly the same effects as the system.

The kite is a body which is rigid within the present meaning, and, when flying, is acted upon by a complex system of forces. The conditions of equilibrium or motion are these:

When the couple $Z_0=0$, and when the string pulls in a direction opposite to the force R_0, and exactly in line with it, then the kite will be in equilibrium. If, however, the couple Z_0 is finite, while the string constantly neutralizes the force R_0, then the kite will spin around upon the string as an axis of rotation, the kite as a whole remaining fixed in one position. If on the other hand, the pull of the string does not balance the force R_0, but the couple Z_0 still remains zero, then the kite will be translated in some direction without rotation. Finally, if Z_0 be finite and the force R_0 is unneutralized by the restraint of the string, then the kite will be both translated and will also rotate about the string as an axis. All the evolutions any kite may execute are but combinations of the foregoing cases, as will be more fully discussed hereafter.

While we may thus, by the fundamental propositions of mechanics, pass at a single step from the conception of the highly complex system of forces due to the action of wind and gravity upon every point and particle of the kite to its exceedingly simple equivalent, and establish all the circumstances of motion or rest, by doing so we omit from consideration many relations between the forces of the system that are of great practical importance and utility, especially in the designing and constructing of kites to perform any assigned duty.

Before discussing, therefore, in full, the specific causes of the various motions kites are observed to execute, we will analyze in detail the forces acting upon kites in general.

IV.—FORCES ACTING ON KITES IN GENERAL.

In flight, the forces acting upon a kite and its line are: (1) The total of all the wind pressures upon the whole structure, including pressures upon not only the sustaining surfaces but upon every part of the framework, also all friction effects of the wind gliding over the surfaces, etc.; (2) The attraction of gravity for the kite; (3) The tension of the string at the kite, that is, the restraining pull of the line;

(4) The attraction of gravity for the string; (5) The pressure of the wind upon the string; (6) The action and reaction of the forces at the reel that restrain the whole system. If the kite is provided with a tail, one more composite force acts in addition to the six mentioned above, namely, (7) the resultant of the forces of the wind (W) and gravity (G) upon the tail. When a kite, or tandem of kites, is employed to lift and sustain objects in mid-air, such as meteorological instruments, photographic apparatus, etc., these may be attached to the kite frame itself, in which case the pressure of the wind against the object and its weight may logically be considered with the forces (1) and (2) above. It is not, however, customary, as a rule, to carry such loads in this way. The apparatus is generally suspended from the line at some point below the top end. In this case the forces of wind (a) and gravity (b) acting upon the attachments are properly considered in connection with the other forces (4), (5), and (6) acting upon the string. If the forces (wind and gravity) acting upon the short piece of string or line employed to suspend the instruments are not inappreciable, then those forces, also, if not included in (a) and (b) above, must be treated separately.

Under the circumstances cited all of these forces are concerned in determining the positions of equilibrium assumed by a kite flying freely in mid-air. In studying the mechanics of the kite proper, however, we are concerned only with the equilibrium of the forces (1), (2), and (3), including (7), if the kite has a tail. We need to consider the string and the forces acting thereon only when we wish to know how high a given kite can fly, or the position it will assume when carrying a given load with a certain length of line, etc.

Having thus called attention in a general way to all the forces upon which the action of any kite depends, we will omit from present consideration the string and its forces and proceed first to develop the relations upon which the equilibrium of the kite itself depends, that is, the relations between the forces (1), (2), (3), and (7).

In order that the reader may form a mental picture of just what we now desire to consider, he may imagine a kite in mid-air under conditions of free exposure to the wind but held in restraint by a comparatively short piece of string or line. The action of gravity and the wind upon this short line being inappreciable, it will therefore be sensibly straight. The direction in which this string is pulled; the inclination of the surfaces of the kite to the wind; the action of the tail, when present; the variations of the several forces with changes in the character of the wind; the process by which the kite once in equilibrium is able to reestablish equilibrium under constantly changing conditions of the wind—are the questions with which we are now concerned.

The force (2) is wholly and simply a gravitation effect, and is, therefore, perfectly constant in amount and direction. The tension in the short piece of restraining line and its direction constitute the restraining force (3) which always acts through the point at which the line is fastened to the bridle or kite stick, as the case may be. This force (3) is not an independent force; it exists and undergoes variations only as a result of the action and variation of the other forces specified. Of the remaining forces, (1) is wholly and (7) partly a wind effect of comparatively complex character and subject to variations of great frequency and very considerable magnitude. In order to set forth fully the effects of the wind pressure upon the kite, as we now imagine it flying upon a short straight string, it will be necessary to analyze in some detail the nature and composition of the forces (1) and (7), which together embrace the total effect of the wind upon the kite and its tail. We are particularly concerned with (1) which includes by far the most important forces with which we have to deal. For the purpose of this analysis it will be convenient to classify the several portions of the kite structure, as follows: Sustaining surfaces; framework; edges; neutral surfaces; and finally the tail, which consistently belongs within this classification, notwithstanding that the forces acting thereon have already been specified under (7). In some specialized and uncommon forms of kites perhaps portions of the structure may not fall within this classification; it will suffice, however, for our present purposes, as we seek to show only the ultimate effect resulting from the pressure of the wind upon the entire structure of the kite. We embrace under "sustaining surfaces" all those extended surfaces of cloth, paper, or similar material whose normal function is to sustain the kite as a result of the pressure of the wind thereon. In many forms of kites, especially of oriental types, we find the most remarkable diversities in the shapes of the supporting surfaces. The logical inference we may draw from this diversity of itself is that the mere shape of the surface is of little importance. As we shall see, the continued flight of kites depends upon the action of certain forces, one of which is the pressure of the wind against surfaces. There is scarcely any limitation to the form of surface that may be used. The necessary force is produced and can be made to act in proper relation to the other forces with almost any surface whatsoever.

The framework, in the present classification, includes all the sticks, struts, ties, braces, and those members of the structure that spread out the sustaining surfaces and give form to the kite. The group entitled "edges," includes principally any exposed edges of the cloth or covering material. These are usually reinforced by a hem, or otherwise thickened, often with the addition of a cord within the hem. While the wind pressure upon such "edges" will generally be relatively unimportant, yet it is very proper to recognize them in our analysis. Finally, an example of neutral surfaces is found in the fin or keel of the Boynton kite, and in the lateral surfaces of the rectangular cells of a Hargrave kite.

Primary characteristics of wind pressures.—It is well known that the pressure experienced by any object exposed to the action of the wind is due not alone to the direct impact of the air on the front or windward surface, but also to the diminution in the static pressure over the back surface or lee side of the object. For our present purposes we need not push the analysis so far as to separate these effects, and we will in all cases regard them as combined into one resultant pressure exerted against the front side of the object under consideration. In dealing with surfaces exposed to pressure we wholly disregard the edges. The effect of pressure upon the edges is reserved for separate consideration.

Whenever the wind encounters a perfectly smooth surface which causes a change in the direction of motion of the current, the surface experiences a pressure which acts exactly normal to every element affected. This is a fundamental and well known principle of hydrodynamics and finds important application in the theory of the kite.

In the case of slightly roughened, fuzzy surfaces, such as the cloth used in kites, the surface can not be regarded as perfectly smooth, and there will in consequence be a friction effect resulting from the flow of the particles of air over such rough surfaces. The air may be regarded as pressing against the minute projections and irregularities which constitute the roughness of the surface, and a relatively slight force is thereby developed which tends to urge the surface along in the direction in which the streams of air are flowing over it. This effect of skin friction combined with the pressure normal to the surface gives the total effect of the wind on the supposed roughened surface. Obviously, this total effect is a pressure which is not quite normal to the surface but will be inclined thereto more or less in proportion to the relative magnitude of the friction effect. Having thus recog-

nized and assigned the proper place to the effects of skin friction, it will scarcely be necessary to give it further consideration, since, as is well known, the effect is so small, relative to the principal forces acting on kites, as to be quite unimportant. Without further mention, therefore, we will hereafter consider that the slight effect due to friction is included with the normal pressure against the surface. Furthermore, we will still designate this combined effect as the *normal pressure* since in practical cases it will be sensibly perpendicular to the surface.

Pressure upon sustaining surfaces.—In accordance with the characteristics of wind pressures, as enunciated above, the whole effect of the wind's action upon the sustaining surfaces, either flat or curved, of any form of kite whatever, consists of a pressure sensibly normal to the surface at every point.

Flat surfaces.—If the sustaining surfaces are flat, the normal pressures are parallel to each other, and the total effect of all the individual pressures may be represented by a single force or pressure acting sensibly normal to the supposed flat surface and at a point commonly called the center of pressure, which is a point through which the resultant force must act to produce the same effect as the individual pressures.

Curved or arched surfaces.—The sustaining surfaces of kites, being generally formed of yielding materials, such as cloth or paper, will, whether designedly or not, form curved surfaces when pressed by the wind. This curvature will sometimes be wholly in one direction, either coincident with the direction of the flow of the particles of air across the surface or at right angles thereto; whereas in many cases the surface will be curved in all directions. In any case the individual pressures at elementary points upon such surfaces must still be regarded as sensibly normal at each point, but the direction of the resultant pressure can rarely or never be fully assigned by any of the principles of hydrodynamics thus far established. The direction may be partly predetermined by known laws in some cases, but, in general, it can be fully established only by aid of experimental investigations. This is especially the case when the surface is curved in the direction in which the particles of air flow across it. Data of this character are comparatively scanty and incomplete, often obtained by erroneous methods, so that we can not, even from experimental results, definitely assert more than a few general conclusions relative to the pressure of wind upon arched surfaces. Much has been written upon this subject, and especially upon the asserted property of "aspiration," by virtue of which the pressure of a *horizontal* wind upon a properly disposed arched surface is able not only to sustain it, but also to propel it forward. Such a remarkable performance is undoubtedly in direct violation of the fundamental laws of nature, and, in the numerous cases where it is claimed not only that birds in the free air have been certainly observed to exhibit aspiration, but that these effects have likewise been fully reproduced with artificial free-flying models, it is easy to show that these claims are wholly unsupported by any evidence that the wind was strictly in the *horizontal* motion virtually assumed. Lack of proof on this point alone is fatal to the claim that any case of real aspiration has been observed or reproduced. Lilienthal, Langley, Maxim, Wellner, F. von Loessl, and others have conducted extensive experimental investigations upon aerodynamic problems, but, as far as known to the writer, the results of several of these investigations have been only partly published up to the present time. The most completely published results of wind effects upon arched surfaces is found in Lilienthal's book[1] and in a pamphlet by Wellner.[2]

The conclusions reached independently by these investigators are practically the same as regards the main features. Their results show: (1.) That the resultant pressure of the wind upon arched surfaces inclined at moderate and small angles of incidence is from two to three times the pressure upon an equal area of flat surface similarly inclined. (The inclination of the arched surface here refers to the inclination of the plane in which the chords of the arch are assumed to lie.) (2.) The action line of this resultant pressure, when the surface is placed at certain favorable angles of incidence, ranging from about 0° to 25°, was found to intersect the chord of the arch at an angle *greater than* 90°, and in such a sense as to produce a *forward propelling component;* that is, if *A C B*, Fig. 1, is a section of an arched surface by a vertical plane parallel to the lines of flow of the wind across the surface, and *P C* the resultant wind pressure, then the angle *A O P* is found to be greater than 90°.

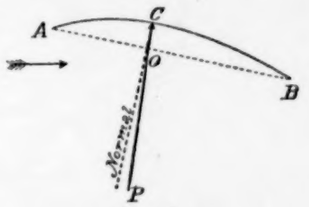

FIG. 1.

The second of these results is of special importance in designing kites intended to attain very great elevations. As yet, however, it can not be admitted that these conclusions are fully established. A. v. Obermayer[3] has called attention to a serious source of error in the methods employed by both Lilienthal and Wellner, and has shown that especially the second conclusion cited above is by no means proven. The real effects of the pressure of the wind upon arched surfaces are, in fact, but very imperfectly known at the present time. The writer has reason to believe that much valuable experimental data on the subject has been obtained which is not yet published.

Center of pressure.—The foregoing discussions relate to the *direction of action* of the resultant pressure upon flat and arched surfaces respectively; we will next consider the position of the point through which this resultant pressure acts, namely, the *center of pressure.* Here, again, the general laws of hydrodynamics, so far as known, do not suffice to definitely locate the center of pressure, except, perhaps, in certain simple cases. Its position must, therefore, be sought by means of experimental investigations. Joëssel, Kummer, Langley, Lord Rayleigh, and others have contributed to this question. Joëssel's results were published in 1870. Those of Kummer in 1875 and 1876. The work of Kummer comprises experiments with paper bodies modeled to resemble heavy shot and cannon projectiles. The position of the center of pressure was also determined for square and rectangular planes formed of sheet tin. These, however, he found were bent by the pressure of the wind, thus causing erroneous results, so that afterwards he was led to repeat his observations on plane surfaces, which, for this purpose, were made of thin plates of glass. While his results are strictly applicable only to small bodies (planes 90 by 180 mm. and less) moved at moderate velocities (less than 18 miles per hour), his experiments are quite as comprehensive as any. Langley's investigations are of more limited scope (confined to a plate 1 foot square), but the results, so far as they go, bear internal evidence of high accuracy. Lord Rayleigh,

[1] Der Vogelflug als Grundlage der Fliegekunst. Von Otto Lilienthal. Berlin, 1889.

[2] Versuche über den Luftwiderstand gewölbter Flächen in Winde und auf Eisenbahnen. Von Georg Wellner. Zeitschrift für Luftschiffahrt. Beilage zu Heft X. Berlin, October, 1893.

[3] Uber die Wirkung des Windes auf Schwach gewölbte Flächen. Von A. v. Obermayer. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Heft VIII. Vienna, October, 1895.

from purely theoretical considerations, has deduced a formula, stated below, giving the position of the center of pressure on plane surfaces. There is a remarkable agreement between the theoretical formula of Lord Rayleigh and the experimental results by Langley. If d is the distance from the front, or windward edge of a rectangular plate to the position of the center of pressure, and if l is the length of the plate in the direction of the flow of the air particles across it, and i is the angle of incidence to the wind, then, according to Joëssel:

$$d = l(0.2 + 0.3 \sin i) \quad (1)$$

and, according to Lord Rayleigh:

$$d = l\left(0.5 - \frac{3}{4}\,\frac{\cos i}{4 + \pi \sin i}\right) \quad (2)$$

The formulæ given above for the position of the center of pressure are strictly applicable only to simple rectangular *flat* surfaces. Kummer's work conclusively demonstrates that even a slight curvature gives rise to very considerable differences in the position of the center of pressure. It therefore results that the general laws of hydrodynamics, and even the results of any direct experimental investigations thus far known, will be of little or no assistance in correctly locating the position of the center of pressure of the wind upon ordinary kites, because their surfaces, even when of the simplest form, will be so different from those employed in experimentation or considered in theoretical deductions that laws thus determined can not apply.

Much looseness prevails in the use of the term *center of pressure*, and it is very important that a clear idea be formed of its exact mechanical significance. When we think of the pressure of the wind upon an infinitely thin and rigid smooth plane we are dealing with a system of parallel elementary pressures acting at every particle of the surface, and there is then a very close analogy between the center of pressure, that is the point at which the resultant may be conceived to act and the center of gravity, for example. This center, whether of gravity or wind pressure, can, however, have a real existence *only* when the forces are unaffected by angular alterations in the position of the body. This is regarded as true in our ordinary dealings with terrestrial gravitation, but obviously when we deal with wind pressures upon material objects, even of the simplest form (and much less so with the complex devices we call kites), the forces of the system are no longer parallel, and even if they were the slightest modification of the angular relations between the body and the wind would change in a corresponding manner the whole system of forces. Under these circumstances no real mechanical significance can be attached to the so-called center of pressure, except that it is *some* point on the action line of the resultant of the whole system of forces. We may, for example, imagine the center of pressure to be the point where the action line of the resultant intersects the surface of the body, but we may just as logically imagine it to be a point within the interior of the body, or any other point on the line of the resultant. In fact, in the mechanics of the wind pressure upon material objects there is no such thing as the center of pressure. The thing which does, however, have a real existence is a *central axis*. It is a line, not a point, we are to think of in this connection as having some mechanical significance, and when we wish to limit our consideration to some specific point of this *central axis* as the origin of a force its significance is simply that of an assumed point of application of the force.

Summary.—The foregoing analysis of the pressure of the wind upon sustaining surfaces of kites leads us to the following conclusions: (1) The resultant pressure (including skin friction) is sensibly normal to flat surfaces, and under favorable conditions the resultant pressure upon arched surfaces may possibly be so inclined that a component will act in a direction forward of the normal to the chord of the arch. (2) When the edges of thin rectangular flat surfaces are presented respectively perpendicular to and in the same plane with the direction of the wind then the *central axis* of the system of pressures intersects the surface at a point (center of pressure) which is given with a close degree of approximation by Lord Rayleigh's formula, equation (2) above. For flat surfaces not rectangular in form or presented to the wind otherwise than specified and for the complex and multiple flat and arched surfaces usually found in kites the position of the *central axis* can not be located, *a priori*. (3) The intensity of the pressure upon slightly arched surfaces at small angles of incidence, such as those at which kites are ordinarily flown, is, upon the authority of Hargrave, Lilienthal, and others, considerably greater than upon an equal area of flat surface at the same inclination.

Pressure upon the framework.—The framework of the kite contains a variety of surfaces which are presented to the wind in a great diversity of ways. Some are completely sheltered behind the sustaining surfaces, others are partly, and many, especially in cellular kites, are fully exposed to the wind's action. The general characteristics of wind pressures already enunciated will fully suffice for analyzing in detail the effect of the wind upon the framework. Such an analysis, however, is not now required. Whatever the pressure of the wind may be on the individual surfaces its total effect may be represented by a single line of appropriate length and direction. The point of action of this total effect can not, in general, be exactly located. This, however, is not of special importance, since the whole force is small compared to the main pressures acting upon the sustaining surfaces. Owing to the favorable disposition of a considerable portion of the surfaces of the framework the pressure of the wind thereon will be partly beneficial in character, that is, it will have at least a slight lifting tendency and, as a result the line representing this total effect will have an upward inclination.

Pressures upon edges.—At least portions of the exposed edges of the covering material of kites are subjected to pressures which are not treated of under either of the foregoing topics. These pressures are now considered, and, as in the case of the framework, the whole pressure may be summed up into a total effect, which can be represented by a certain line. The point of action of this total force also can not be located with accuracy, but this is of very slight consequence. Any unbalanced upward or downward pressure upon the edges may be regarded as a pressure belonging properly to those upon the sustaining surfaces themselves, and should be included in the resultant pressure thereon. As a consequence of this the action line of the resultant pressure on the edges will be horizontal.

Pressure upon neutral surfaces.—These surfaces are designed to be neutral under conditions of normal flight and should, therefore, experience only equal pressures upon the opposite sides; the pressure upon the exposed edges belongs properly with the class considered in the preceding paragraph. Owing to imperfections in the kite structure and lack of perfect symmetry of corresponding parts, it will probably never happen that the neutral surfaces are really neutral as regards the equality of pressure upon opposite faces, so that even during steady flight there will be a slight excess of pressure upon one side of such surfaces. The real function of neutral surfaces is to steady the kite during variations in the wind force, and this action will be considered when discussing the stability of the kite under variable winds.

Forces of wind and gravity upon tails.—As ordinarily made the tail consists of long strips of cloth, often with a bushy tassel at the free end. A better form consists of tassel-like bunches of paper or cloth tied together at intervals on a

length of string. Probably the most efficient device for the tail consists of a series of light, hollow, cloth or paper cones, strung together upon a string or wire and presented with their bases to the wind. All such tails are fastened to the kite by a piece of string or equivalent flexible attachment, and they will therefore draw away from the kite in a direction which is the action line of the resultant of all the forces affecting the tail at the kite. The direction of action and the intensity of this resultant force is all that now concerns us in our study of the mechanics of the kite. To fully determine these data experimentally for specific cases, it will suffice to detach from the kite the tail whose constants are desired, and fasten it to a suitable dynamometer, Fig. 2, placed in neutral equilibrium as regards both wind and gravity, and provided with a graduated arc for measuring the angles of deviation from the vertical assumed by the tail when exposed freely to the action

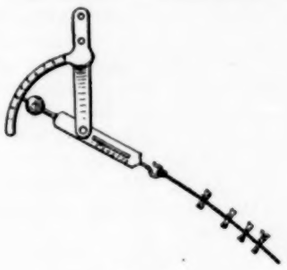

FIG. 2.

of the wind. By this means the resultant force exerted by a given tail in winds of different velocities may be fully established, which data are the constants of that particular tail.

Kites may be provided with other appendages than described above which answer some of the purposes of a tail. These may resemble the tails of birds or have rudder-like effects. Such devices are, in fact, a part of the kite structure itself, being more or less rigidly connected therewith. Appendages of this character are generally very pliable and easily flexed by the pressure of the wind, and their efficacy will often result from vibratory, fluttering motions which they acquire under the action of the wind, and which are discussed in the following paragraph:

Effects of fluttering, waviness, etc.—Throughout the analysis of the action of the wind upon the structure of the kite it has been virtually assumed that all portions are quiescent relative to each other. If the action of the wind causes fluttering and produces a more or less permanent system of waves over the pliable material of which kite surfaces are generally made, or, if the kite structure is provided with special members which are designed to be set in vibration by the wind for the purpose of producing musical sounds, etc., as is the case, for example, in some of the ingenious oriental kites, then whenever such effects are present there will be called into action an additional force, not thus far considered, and which will result from the action of the wind upon the wave fronts, etc. By reason of this action the surface so affected will tend to be pushed along in the direction in which the streams of air flow across it, just as a flag, for example, with its surface formed into a multitude of waves tugs at its halyards with much greater force than if the waves were wholly absent. We may, therefore, represent the effect of waviness and fluttering by a line parallel to the general flow of the air over the kite surfaces.

Whirls, or eddy effects.—There is another circumstance which may produce an effect not thus far considered. In some forms of kites a greater or less portion of the whole current of air affected by the presence of the kite is broken up into numerous whirls, or eddies. These may be formed when the air flowing against the kite is suddenly stopped, or when its movement is abruptly changed and diverted to a new direction. Angles and changes in the continuity of the surfaces such as formed by the presence of the cross stick in the malay kite, for example, and other causes that prevent the air from flowing easily and by smooth changes of motion over and past the kite will give rise to eddies. Whirls of marked character exist over the leeward surfaces of the kite. Strong eddies may thus be set up at numerous points adjacent to the body or surfaces of the kite. It is possible, and indeed quite probable, that some of these may remain nearly stationary in certain favorable spots. Such eddies, or whirls, in a certain sense, may have much the same effect as obstructions to the flow of the air. Quite as much of an obstruction may be thus formed as if an excrescence of rigid material were placed on the kite at one of the points in question. In cellular kites generally the cells are virtually short tubes through which large streams of air must flow. Pronounced eddy formations within these tubes have much the same effect as real obstructions by which the flow of the air is, as it were, choked up. We perceive, by the aid of the comprehensive principle of the conservation of energy, that the power required to form these eddies and maintain the air within them in rapid motion must be derived by reaction from the kite and its string. The necessary reaction can be derived from the kite only when the resultant forces acting thereon experience some modification, depending upon the presence of the eddies. The nature of this modification must be equivalent to a force which tends to cause the kite to move in the direction of the general current of air. The eddy effect may, therefore, be represented by a horizontal line.

Combination of all wind effects.—We have now separately analyzed the action of the wind upon the several more or less essential members present in all forms of kites. We have also shown the general characteristics of the resulting forces so far as they are of importance in the theory of the kite, and called attention to the effects of waves and eddies. Let us next combine these several elementary effects, and thus ascertain the general total effect due to the action of the wind upon the whole structure of the kite. This total effect of the wind is the force we have designated (1) above.

In assigning a magnitude and direction to any of the several wind effects it is to be observed that the wind is not constant either in force or direction, nor is it even homogeneous. We therefore assume that the value of all those wind effects whose interrelations we wish to study are *momentary values, simultaneously taken*. Furthermore, owing to this momentary character of the forces, the kite is constantly obliged to shift its position in order to adapt itself to the ever changing conditions. At any assigned moment the kite is, therefore, doubtless already in motion as a result of the relations between the forces of a previous condition. Recognizing this circumstance, which is of great importance in the dynamics of the flight of birds and flying machines, but yet of only passing interest in the statics of kites, we assume that, in view of the small mass of the kite, in relation to the large forces acting thereon, a condition of rest promptly ensues whenever equilibrium exists between the forces, and that the movement executed by the kite at an instant when equilibrium does not exist is modified in only an unimportant degree by reason of the momentary velocity the kite may then possess.

The several partial effects of the wind upon the different members of the kite structure, namely: the resultant normal pressure of the wind upon the sustaining surfaces, N; the total effect of the wind upon the framework, f; the total pressure effect of the wind upon the edges, e; the excess of pressure upon one side of neutral surfaces, n; the total effect due to waves and fluttering, w; and, finally, any effect due to the presence of eddies or vortex motions, v, can all be combined

in a simple manner by aid of the graphic methods employed in mechanics. These depend upon the following fundamental propositions, namely: *Any system of forces is equivalent in effect and may always be reduced to a single force and a couple, and the force may be made to act through any point.* Also: *When a system of forces has been reduced to a single force and a couple there is but one position of the force possible in which the axis of the couple will be parallel to the direction of the force.* This position of the force is called the *central axis of the system.*

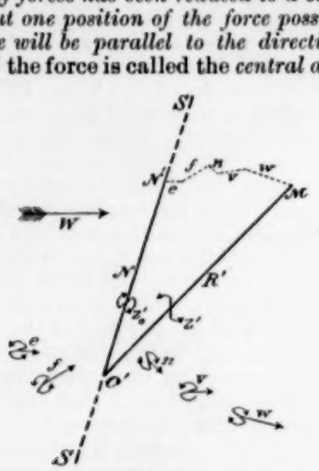

FIG. 3.

Let *S S*, Fig. 3, be the *central axis* of the system of wind pressures acting upon the sustaining surfaces of any kite. Then by the above cited proposition of mechanics our so-called normal resultant pressure, *N*, will act in this line. (It may be remarked that if the sustaining surfaces consist of flat surfaces in parallel arrangement then the *central axis* will be sensibly normal thereto, but in general there will be a complex set of surfaces inclined to each other and probably curved; in this case *S S*, and with it the so-called normal resultant, *N*, will no longer be normal to the sustaining surfaces; furthermore, *N* is designated a normal resultant simply because it is the resultant of a system of elementary wind pressures, each sensibly normal to its corresponding elementary surface.) Let *C'* be the assumed point of application of *N*. In single surface kites we may take *C'* where the *central axis* intersects the surface, but in cellular and in other kites we may take some other point. *C'* may, in any case, be taken at any point on the *central axis* and rigidly connected with the kite. Let *C' N'* represent the magnitude of the resultant, *N*. It is not to be supposed, as is generally done, that a force like *C' N'* represents the total effect of the wind upon the sustaining surface of the kite. We must also recognize a possible couple Z'_0, which, in this case, as required by the proposition cited above, acts in a plane perpendicular to *C' N'*. (When a force and a couple are in perpendicular planes the couple will be designated with a subscript zero.) The possible existence of a couple of this character is but rarely or never recognized in the discussion of wind pressures upon surfaces, but, as we shall see hereafter, it is a factor of vital importance in the mechanics of a kite. Let the couple be indicated on the drawing by the *Z*-formed character, thus:

Z appended to the action line of the force with which the couple is supposed to be associated. The arrow points indicate the direction the couple turns. As we shall presently find, it is necessary to deal with couples which do not act in a plane perpendicular to the force with which they may be associated, we shall adopt the convention of indicating this fact by modifying the symbol, thus:

In proceeding further to represent in Fig. 3 the remaining partial effects, *e*, *f*, *n*, *v*, and *w*, of the wind upon the kite, it is to be noticed that each one of these effects, for example, the resultant pressure of the wind upon the framework, is the resultant of a complex system of forces and according to our fundamental principle each system is reducible to a single resultant force and a couple in a plane perpendicular to the force. These resultant forces are not necessarily in the same plane as the principal wind pressure, *N*, nor even parallel to such a plane. Moreover, we can not assign, *a priori*, any fully logical relation between the position and magnitude of any one of these resultants and those of another or the resultant *N*. But this is not of any consequence, as will be shown. We are, however, able to affirm something as to the *direction* in which the forces act. This was done in a general way when the several effects were separately discussed. Obviously, the tendency of all these effects is to force the kite leeward. The pressures upon the framework, for example, may have a slight supporting component; an excess of pressure upon one side of a fin or neutral surface may push sideways at a high angle, but all the forces *trend to leeward.* If this be not so, then we are confronted with the absurd or impossible consequence that the wind, blowing against a body of assignable form, but uninfluenced by any other forces, as for example is the case if the body is cast free in the wind and has the exact density of the ambient air, is able to cause this body to *move steadily to windward.* "Aspiration," in its essence, is not more nor less than this impossible consequence.

The projected direction of the wind is shown at *W* and in conformity with the foregoing we have shown, in Fig. 3, the projected positions, chosen at random, of the several partial wind effects, each associated with a couple. We do not affirm that any of these couples necessarily have finite values. We need not say more than that each of the several forces is the result of the action of a complex system of forces applied at innumerable points of the kite structure and the principles of mechanics require that the possible existence of these couples be recognized.

As we have said, the relative magnitude of the forces can not be accurately assigned. Compared with *N* the others are all small, much smaller than shown, as the lines in the diagram are made longer than logically proper simply for the sake of clearness. The force, *N*, is by far the largest and most important force acting upon a kite, and each of the other forces may be regarded as a small disturbing influence superposed upon the primary effect *N*, which is due to the relatively simple pressure of the wind upon the sustaining surfaces. We have thus shown by groups in Fig. 3 all the forces due to the wind that may act upon any kite. The combined effect of these constitute the force we designated (1) in our original category. It will be remembered, too, that other forces were enumerated as acting on the kite, namely, gravity (2) and the pull of the tail (7). We will not at once combine all these forces into a single resultant, as we might do, but we will first combine only those shown in Fig. 3, in order that we may thus ascertain the total effect of the wind, and at the same time be able to show how the several small modifying and disturbing forces and their changes affect the final result.

By the principle of mechanics that any system of forces is reducible to a single force, acting through any point and a couple, we obtain for the system of forces shown in Fig. 3 the single force, *R'*, acting through *C'*, and the couple shown at *Z'*. The single equivalent force is found graphically by means of the well-known principle of the polygon of forces applied as indicated by joining to *C' N'* the broken dotted line made up of parts parallel respectively to the forces, *e*, *f*, *n*, *v*, and *w*, thus giving the resultant *R'*. Thus far we have not affirmed anything of the plane of the diagram, except that it contains the force *N*, we now assume that it was so chosen as to contain also the resultant *R'*. It is to be noted,

however, that the other forces are not necessarily in this plane nor parallel to it. The couple, Z', not only represents the effect of the several original couples, but also includes the couple resulting from the combination of the system of forces, N, e, f, n, v, and w. The full identity of this couple can not be determined *a priori*. We know, however, that its axis need not necessarily be parallel with the resultant R'. The fact that the possible existence of a couple is recognized is sufficient for our present purposes and its whole effect will be taken into account when we come to establish the conditions necessary for equilibrium.

The following analysis brings out the effects of the small forces we have called disturbing influences. Suppose all these forces are so small that they may be neglected, the resultant, R', will then be sensibly coincident with and equal to N. No one of these partial effects tends to neutralize that of another. All combine to increase the angle included between N and R'. The magnitude of R' will depend, in a secondary and unimportant manner, upon the disturbing forces. The resultant, R', will be exactly the same as shown, no matter what positions may be chosen for the partial effects, provided their magnitude and direction remain the same. We have shown that the direction of action of all these forces *must trend to leeward*, and whatever finite values and rational directions may be assigned to these forces, it is clearly demonstrated that, by reason of their disturbing influence, *the action line of the total wind effect on any kite is deflected away to leeward from the direction of the resultant pressure upon the sustaining surfaces*. Furthermore, the fact that these several forces can exist in nonparallel planes is sufficient to produce a final resultant couple, and, as we shall see hereafter, the presence of a couple among the forces acting upon a kite may be the source of much mischief.

The complex nature of the forces resulting from the action of the wind upon all the parts of the kite has necessarily involved a corresponding intricate analysis in order to clearly set forth the real character of that action.

Like all systems of forces this system (1), as we have found, is reducible to a force, R' (which in the present case we have arbitrarily chosen shall pass through the point C'), and a couple, Z'. Let us next combine all the forces acting upon the kite, namely, (1), (2), and (7).

Combination of all the forces.—In Fig. 4, let $C'M$ represent the total pressure effect, R', of the wind upon the entire structure of the kite. (The deviation of the force, R', in Fig. 3, from the normal resultant force, N, was unduly exaggerated for the sake of clearness in that diagram. The line, R', in Fig. 4 is given a less pronounced deviation.) Let (2) represent the projected force due to the weight of the kite, acting at its center of gravity, and (7) the force exerted at the kite and due to the influence of wind and gravity upon the tail. The forces (2) and (7) are not necessarily in the same plane as R'. On the average the tail will generally dispose itself in a vertical plane, and the forces (2) and (7) might, therefore, be regarded as in the same vertical plane; but there is no advantage in thus specializing our analysis, and we will, therefore, regard the forces (2) and (7) as in different planes. T and g are the projected positions of the points of attachment of the tail and the center of gravity, respectively.

All the *independent* forces that in general may act upon any kite are now fully recognized and represented in the diagram, Fig. 4. The restraining pull of the line, as already pointed out, is not an independent force, but exists as a result of the combined action of the other forces. This pull of the kite line is the force that is to put the whole system of forces in equilibrium.

The combined effect of the forces, R', (2), and (7), may, as we have seen, be reduced to the single force, R (obtained by aid of the polygon of forces, as indicated), and a couple, which we will designate by Z''. Let the two couples, Z' and Z'', be compounded by the methods of mechanics into the single resultant couple, Z, which will be omitted from the diagram to avoid confusion of lines. In Fig. 4 the plane of the diagram is so chosen as to contain both forces, R' and R.

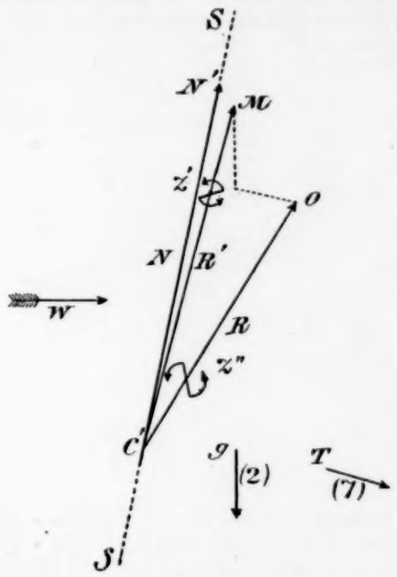

FIG. 4.

This force, R, and the couple, Z, are the final desiderata in our analysis of the action of the forces upon kites. We have aimed to include in the derivation of this result every possible force that can in any way affect the position assumed by a kite in the wind. The direction of action of the force R is the direction in which the kite will tend to move under the combined influence of all the forces. The function of the string is to restrain the kite and prevent this motion. The magnitude of the force R is the measure of the force with which the kite will "pull." The relation which R bears to the elementary and partial effects of the wind, viz, the partial effects, N, e, f, n, v, w, and the important forces, (2) and (7), has been fully shown in connection with the diagrams, Figs. 3 and 4. Z is a couple which tends to turn the kite about an axis not yet determined, but not necessarily parallel to R.

Having thus fully established, in the most general manner, the character of the combined effect of all the independent forces acting upon any kite, we will proceed at once to indicate the conditions that must be satisfied in order to produce equilibrium.

V.—CIRCUMSTANCES OF EQUILIBRIUM AND MOTION.

The problem presented for present consideration is: Given the force R and the couple Z, which represent the combined and total effect of all the forces due to wind and gravity that may act upon any kite, to find how the string or kite line shall be attached in order to produce equilibrium and to explain the various movements of a kite.

Let $C'O$, Fig. 5, represent the resultant force R as found in Fig. 4. Also, let Z represent the couple resulting from the combination of Z' and Z''.

We have added to the diagram a pictorial representation of a common form of kite, in order to assist the mind in grasping the general relations we seek to establish, but this can not in any way limit or confine our conclusions to that specific form of kite, for the whole analysis of the forces has, from the first, been conducted upon the most general lines possible, and the conclusions apply equally to all kites.

The point C', it will be remembered, is the point of application of the resultant normal wind pressure upon the *sustaining surfaces*. It is intended to show the point, C', displaced slightly from a perfectly symmetrical position with respect to the figure of the kite. The reason for this choice is that in all kites unavoidable defects of construction and inequality of effects will cause the position of C' to be more or less eccentric.

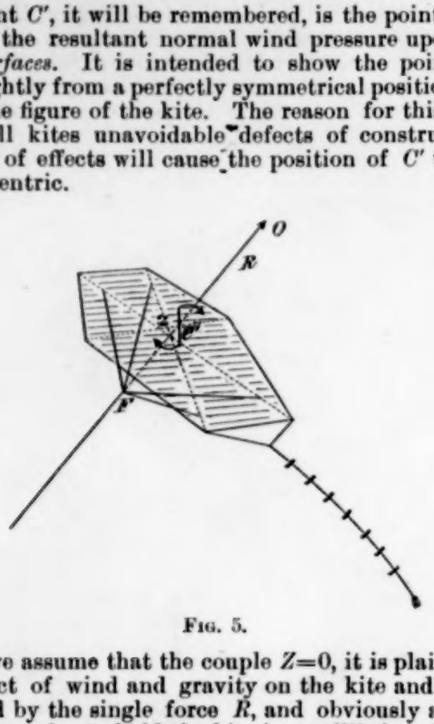

FIG. 5.

If now we assume that the couple $Z=0$, it is plain that the entire effect of wind and gravity on the kite and its tail is represented by the single force R, and obviously all that is necessary in order to hold the kite in equilibrium is that the string shall be so fastened to the kite that its action line (that is, the string prolonged) shall be able to coincide with R. This is the condition shown in Fig. 5, and the point C', it will be remembered, is the point where the *central axis* of the system of *sustaining pressures* intersects the kite. It is also the point at which the *central axis* for the *entire system*, including every force, intersects the kite. We thus recognize that $Z=0$ affords a special case of possible equilibrium, yet, owing to the necessarily rare occurrence of such a condition, we give it no further notice.

Equilibrium when Z is finite.—Equilibrium is possible, but with some limitations, when Z is finite, and provided further that its axis is not parallel to R. In Fig. 6 let the axis of the couple be inclined to the direction of R. By the methods

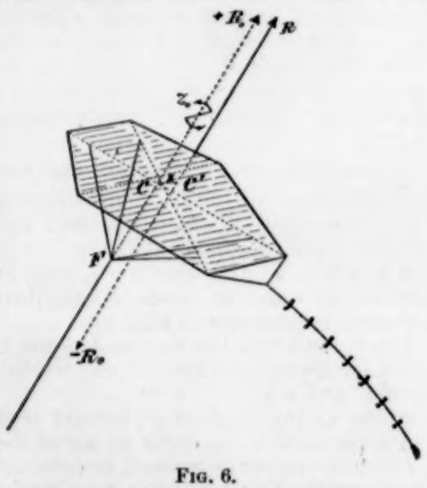

FIG. 6.

of mechanics this couple can be resolved into two component couples, one having its axis parallel and the other perpendicular to R. Let the parallel component be designated Z_0, and the other one P. The forces of the latter couple will be in a plane parallel to R. Now transform the couple P into one whose forces $+R_0$ and $-R_0$ are each equal to R. The arm of the couple will then be $x=P\div R$. Move the couple parallel to its plane and turn it about its axis until one of its forces, $-R_0$, is directly opposite to R. These forces thus neutralize each other, and the whole system of forces has thus been reduced to the couple Z_0 and the single force R_0, parallel and equal to R, and acting in the same direction but at a perpendicular distance, $x=P\div R$, from it. The action line of R_0 now coincides with the *central axis* of the *whole system of forces*, including gravity and the tail. The string can now hold the kite in equilibrium only when $Z_0=0$, and when the bridle or other device for fastening the string is so arranged that the action line of the latter can coincide with R_0. These are the general conditions of equilibrium. The point C, at which this action line of the force R_0 cuts the surface, is often said to be a center of pressure, but had we chanced to show in our picture a Hargrave kite, for example, all our conclusions would hold just the same, and it is possible that the action line of the force R_0 might then have failed to intersect any of the actual surfaces. A center of pressure which has specific, definite, and assignable properties can not exist in the present connection, and we believe that on account of the obscure and indefinable conception of center of pressure generally entertained by experimentalists, investigations upon the position of the so-called center of pressure, and especially measurements of the pressure of the wind upon arched surfaces, have often led to erroneous and even anomalous conclusions.

In the preceding pages we have given an exhaustive and classified analysis of both the principal and the subordinate or modifying forces which act upon any kite. We have endeavored to show the general character and relative importance of the complex effects resulting from the action of the wind upon the whole structure exposed to it. Finally, all the forces have been combined and the general conditions of equilibrium established, as explained in connection with Fig. 6. Our final conclusions are not, however, dependent upon this elaborate analysis of the action of the forces, nor are they affected in any way by faulty or questionable assumptions therein unavoidably made. It is obvious, moreover, that the presence or the absence of any one or all of the several disturbing wind effects we have considered is not necessary to the final results. Any one or all may be infinitesimal and the resultant R' and Z', Fig. 3, may be determined for the the forces that remain, just the same. So again, the presence of the tail is not essential. The force (7) may be made zero in Fig. 4 and the tail vanishes from the mechanics of the problem. The resultant R of the remaining forces is found just the same however. The very general character of the foregoing theory of the kite is thus exhibited.

We have said that the forces which we designated e, f, n, v, and w, were in the nature of disturbing influences that modify the results which would ensue if we had to deal only with the main pressure of the wind N upon the sustaining surfaces. It is also apparent that the effects of the weight (2) and of the tail (7), as shown in Fig. 4, are closely analogous in character to those of the above mentioned disturbing effects. The force (2) in a very direct manner tends to diminish the magnitude of the resultant R, while the presence of the force (7) causes an angular deviation of the resultant R away from R' and N and in a leeward direction. In general, it is desired that what we may call the *upward going tendency* of a kite shall be the greatest possible, while the tendency to go to leeward shall be the least possible; that is, that the *lift* shall be a maximum and the *drift* a minimum. Now with the sustaining surfaces of our kite set in a particular attitude to the wind we get a force N having a certain *lift* and *drift*, whereas, owing to the

presence of numerous disturbing effects, due to the action of the wind on the framework, etc., and these further aggravated by the effects of the weight (2) and the tail (7), we are able to realize out of this original and primary force N, only a modified resultant force R, which has a *less* lift and a *greater* drift than N. The kite is, therefore, by reason of the presence of these disturbing forces, including the weight and the tail, less effective than it would be if there were nothing present but sustaining surface. In the *ideal kite* we imagine all these disturbing causes absent. Such a kite is one, therefore, without weight or tail, and which is made up wholly of *sustaining surfaces.*

Finally, the general conditions of equilibrium developed in the foregoing analysis are identical with those which, at the beginning of this paper, were shown to necessarily follow as the result of the fundamental principles of mechanics.

VI.—EXPLANATION OF THE FLIGHT OF KITES.

In general, kites are restrained by only a single line fastened either to some form of bridle or directly to some point of the framework. More lines than one are, however, sometimes used, as, for example, in the case of dirigible kites. With two independent flying lines, either of which may be paid out or wound in at will, an operator is able to control, within certain limits, the position of his kite in either altitude or azimuth. With three independent strings fastened to the kite at points not in the same line, the operator may cause the kite to ascend or descend as well as fly to the right or the left of the lee point. Such systems of lines are simply equivalent to the well-known bifilar or trifilar suspensions. At a given instant of time, with lines of fixed length and for a certain position of the kite, the forces acting in the several strings are always equivalent to a possible couple and a single force which acts through a determinate point and in a definite direction, which will be parallel to the axis of the couple. If two strings are used the determinate point will be in the line joining the points at which the strings are fastened to the kite or its bridles. With three strings the equivalent force will pass through a determinate point located in the plane containing the three points at which the strings are made fast to the kite. If more than three strings are used the separate forces in them will be indeterminate in relation to the force R_0, but their resultant, when equilibrium prevails, must be in line with and opposed to R_0.

The use of more than one line becomes impracticable in many cases and limits the flight of a kite to moderate elevations.

The explanation of the phenomena of flight given below proceeds upon the assumption that the kite is held in restraint by a single line only. On page 147 will be found some further reference to effects resulting from the use of two or more strings.

Let the reader imagine any kite he pleases launched into the ever-changing wind under the restraint of one string, its behavior is developed in detail as follows:

At each instant, and in each position, the whole effect of the wind and gravity is reducible to a single force R_0 and a couple Z_0, whose forces act in a plane perpendicular to R_0. The kite at first will probably not be in equilibrium because Z_0 is probably finite, but more particularly because the manner of attaching the string to the kite so limits and restricts the possible relations these two may assume that coincidence between the action line of the string and that of the force, R_0, is impossible. Let the condition of affairs at a given instant be as shown graphically in Fig. 7. R_0, assumed to act at C, is the equivalent force; Z_0 the resultant couple of the system; *F is a point through which the string constantly pulls.* The bridle shown in the diagram makes the point F, bear a fixed relation to the kite, yet that circumstance does not limit our conclusions. In whatever manner the string is fastened to the kite, F is to be regarded as simply a point through which the action line of the string always passes, and it may be either fixed in relation to the kite structure, as in the illustration, or it may be capable of moving in some prescribed manner in relation thereto. When a bridle is made of a single bight of string, as in malay kites and those of other forms, the point F is not fixed but is constrained to a circular arc in a plane perpendicular to the midrib.

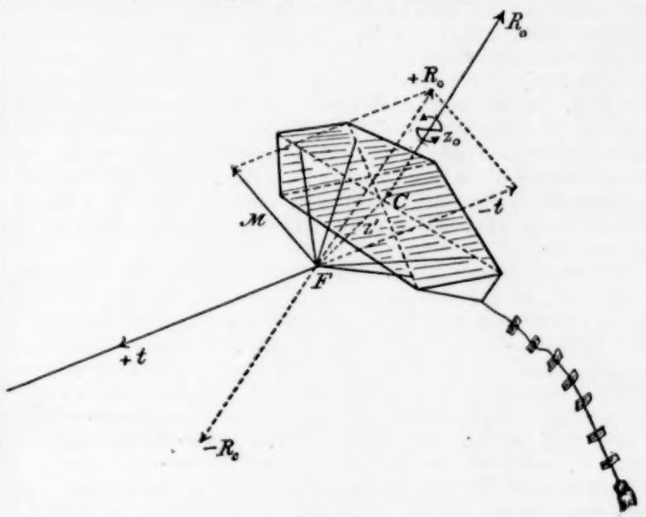

FIG. 7.

Without affecting the system of forces in any way we may apply at F the two equal and opposite forces, $+R_0$ and $-R_0$, each equal and parallel to R_0 at C. The whole system now consists of the "pull," or tension of the line, and the force $+R_0$, both acting at F, also two couples, namely: Z_0 and the couple Z', consisting of $-R_0$ at F and R_0 at C. The movements it is possible for the point, F, to execute are limited and are constrained by the string to be in *a surface, the origin of which is at the fixed end of the string and the radius vector of a point the catenary formed by the string. If the length and curvature of the string are invariable the surface of constraint will be spherical.* To find how the point F will move, we resolve the force $+R_0$ at F into two components, one, $-t$, acting in a direction along the string, the other, M, tangent to the above-described *surface of constraint*, and in the plane containing the string, and the force, FR_0. M, then represents the moving force and shows the direction in which the kite will be moved as a whole; $-t$, is a measure of the pull on the line.

The force R_0, acting at F, has, it will be remembered, been replaced by the two equivalent forces M and $-t$. This latter force calls into existence the tension in the string, that is, our force, (3). The *dependent* character of this force (3) is thus shown. The tension in the line, t, and the force, $-t$, being equal and opposite, neutralize each other, and therefore, may be dropped from the system. There remain, then, the force M, acting at F, and the two couples, Z' and Z_0. Let the latter be combined into a single equivalent couple, Z. In order to understand clearly the effects of the couple Z, we shall find it best to differentiate the kinds of angular movements the kite can execute. For this purpose let us imagine the point F, and the string near the kite to be stationary. Three distinct kinds of movements still remain possible to the kite. For example, it may rotate about an axis passing through F, and parallel to the force, R_0. Secondly, it may tip longitudinally, that is, in a fore and aft sense, about the point F. This motion corresponds to the "pitch" of a vessel

amid waves. Finally, the kite may rock sidewise, that is, careen or tilt laterally, either about the point, F, or about the line joining the fixed extremities of the bridle in case the kite is bridled like a malay kite, for example. This rocking movement corresponds to the "roll" of a vessel.

The axes of the two couples Z_0 and Z' are already perpendicular to each other, hence the one couple can not have any component in a direction parallel to the other, and it will be most convenient to consider the effects of these two couples separately rather than to discuss the action of the equivalent single couple, Z, as a whole. The axis of the couple Z_0 is, it will be remembered, parallel to the force R_0. Let this axis be moved parallel to itself until it passes through the point F. In this case the axis will coincide with the line $R_0\ F - R_0$, Fig. 7. Now the couple Z_0 will make the kite turn its head either to the one side or the other about this line as an axis. At the same time the couple Z' will impart to the kite a movement which in general will consist of both a tip, in the fore and aft sense, and a certain amount of careen or tilt to one side.

It is very important to notice, however, that the movement of the kite, under the action of the couple Z', tends to bring the point C and the force R_0, acting through C, directly in line with the point F. As soon as this occurs the whole couple Z' vanishes from the system; that is to say, its moment arm is zero. The kite will, therefore, tip and careen only a limited amount, and thus assume an attitude to the wind in which the action line of the force R_0 passes through the point F.

It is equally important to notice that no matter how the kite may tip or teeter about the point F, this in itself can have no power to suppress or nullify the turning action of the couple Z_0. The manner in which the action of this couple is controlled will be discussed more fully hereafter.

As a result of the foregoing resolution of the forces acting upon a kite at a given instant of time, the following general theorem is demonstrated. *When the system of forces acting upon a kite is not in equilibrium and is reduced to a single force, M, acting at the point F (the top end of the string), and the couple Z, then the force M will move the kite in a determinate direction tangent to a definite surface of constraint, and under the action of the couple Z the kite will, in general, turn its head to the right or left, will careen laterally to some extent, and tip longitudinally.*

When, therefore, any conceivable form of kite is cast free in the wind and is not in equilibrium under the restraint of its string, incipient motion of the kind defined in the above theorem will ensue. At each moment and at each point of its path, however, the kite is subjected to a new set of forces which differ from the forces of the preceding moment, not only because the wind may have changed, but also because the movement of the kite itself has placed it in a new attitude with respect to the wind, in which new position the forces are correspondingly different, even if the wind be constant. As the kite moves forward and rotates under the action of the couple Z it will, in general, unless it be a very poor kite, promptly assume an attitude in its path such that the couple Z becomes zero and continues sensibly so; that is, its values, when finite, succeed each other rapidly with alternate + and — signs, which means that the kite will execute partial turning movements in opposite directions, and these are often perceptible as rocking, wiggling, tipping, pendulous motions. Moving along its path in this manner the kite presently attains what we will call its *steady position*, which may be defined to be a position in which M has also become zero, or, more exactly, a position in which the values of M are small and rapidly succeed each other in widely diverse directions, while the values of the couple Z_0, if finite, change signs rapidly. The kite does not, therefore, move far in any one direction, but is constantly shifting its position as a result of its efforts to adapt its position to the changing conditions of the wind. In its *steady position* the relation of forces shown in Fig. 6 is approximately established and we are to imagine that the point C at which the action line of the string chances to intersect the surface of the kite, and which is often thought of as a "center of pressure," is constantly shifting from point to point within a limited space in definite correspondence with the movements of the kite and the changes of the wind. In the meantime the couple of the system takes on constantly changing values, but with quickly alternating algebraic signs, which means that the kite rocks and teeters on its bridle strings, turning its head to the right and left as circumstances may require. Such is the progress of a well-arranged kite from a starting point to its steady position, and such are the actions going on in that *steady position* which will become one of *perfect equilibrium* when the wind is perfectly constant in force and direction, provided further that $Z_0 = 0$.

A well-arranged kite is able to glide gracefully up to its steady position simply because, owing to its symmetry and the corresponding equality of the pressures upon the lateral halves of the kite, the force M falls approximately in a vertical plane parallel to the wind direction, to which plane motion of translation must also be confined.

The application of the general propositions of mechanics is sufficient to thus explain every phase of the movements any kite may execute, nor does the theory make any distinction between kites that are good and those that are bad. Any object blown by the wind and restrained by a string is a kite within its meaning, and the darting and gyration, the diving and spinning, the downward as well as the upward or sagging flight a kite may execute when flown from a point well up in the free air—all its evolutions are equally explained and accounted for by the relations that are possible between the force M and the couple Z.

A study of the conditions that contribute to the stability and steadiness of a kite is a most important application of its mechanical theory. Before entering upon such a discussion, however, we will first trace out the conditions and causes of the more characteristic evolutions of flight, and thus be the better able to understand how the flight may be controlled.

VII.—ABNORMAL FLIGHT OF KITES.

Assuming the flow of the wind to be in straight lines and steady, we may regard normal flight to obtain when the kite assumes and holds a steady position which is dead to leeward, that is, when the kite and the string are in a vertical plane parallel to the direction of the wind. Normal flight in a steady position results when the force R_0 is in the vertical plane of the wind and $Z_0 = 0$.

One of the primary and ultimate causes of abnormalities in kite behavior is to be found in the general and fundamental weakness of kite structures. The idea is popularly current that yielding, flexible construction is of great advantage. There is little or nothing in mechanics to support such a claim, and there is much against it. Elastic bending and yielding of a framework is much more likely to take place *unsymmetrically* than otherwise, and distortion of the prescribed figure of a kite is fatal to normal flight. Many of those sudden, unexpected, and unaccounted for evolutions of kites that sometimes occur result wholly from distortions made possible by too frail a construction. When the conditions that are essential to stability have been observed and are *rigidly preserved* in a given structure it will fly steadily enough in all winds its strength is capable of resisting.

Swerve, deviate, sag, are terms we may use to designate certain mild kinds of anomalous flight in which the kite tends

to steadily and continuously fly off to the right or left of the direct lee point. This behavior is, to a moderate degree, characteristic of all kites, and is not of serious consequence unless the tendency is greatly exaggerated and the kite flies far off to one side with a downward tendency, in which case the kite is said by some to "sag."

FIG. 8.

These actions all result from the same general conditions which are primarily a want of symmetry. Let us imagine we have a perfectly normal kite and that its steady position is dead to leeward. Let Fig. 8 represent the kite as seen from a point in front (to windward) and in the plane of the kite. In normal flight the string and the force R_0 will be in a vertical plane and appear as shown. Now suppose that instead of being perfect, some irregularity, of density for example, causes the center of gravity to be laterally eccentric, as at g. All the wind forces on the kite must remain exactly as they were before, since a change of density in a portion of the kite can not affect them. The resultant of all the forces, excepting gravity, will still be represented in the figure by a line in the direction of R_0. Let the force (2) at g now represent the gravity of the kite. This force combined with the force acting along R_0 will give rise to a couple and a resultant, still acting, as it appears projected on the drawing, along the direction of R_0. The couple will turn the kite, thus changing its attitude with respect to the wind and introduce a whole new system of forces leading finally to a new steady position for the kite, which can not possibly be in the vertical plane of the wind.

By similar reasoning it can be shown that a lateral shifting of the point F, or a change in the point of action of the tail, or a lateral displacement of the point of application, C, of the resultant, R_0, will cause the kite to fly to one side or the other of the normal plane. The converse of this is also demonstrated, namely, that if a kite flies, moderately at least, to one side of the lee point, it can be made to execute normal flight by a proper alteration of the position of the center of gravity, or a lateral shifting of the point F, if the bridle is of the rigid type, or by a lateral displacement of the action line of the tail, if the kite has a tail. It does not necessarily follow that bad cases of deviation can always be corrected in this manner.

Sagging generally results from pronounced distortion of the prescribed figure of the kite when subjected to considerable strain from the wind, or from original unsymmetrical construction and possible shifting of the loosely-fitted cover. The defect may not always be apparent or discoverable when the kite is hauled in.

Darting, *diving*, *gyrating*, *spinning*, are other terms that may be used to describe evolutions of the kite. These differ from each other in the main only in degree.

Darting will be considered as referring to erratic and approximately periodic shiftings of the kite from side to side, but without losing elevation; a *dart* becomes a *dive* when the kite pursues a downward course for a time, but recovers and ascends without executing a complete *gyration*. *Spinning* is suggestive enough of the pin-wheel evolutions a kite may execute while standing pretty steadily in one position.

When the resultant force, R_0, of the system and the action line of the string are sensibly in the relation that corresponds to equilibrium, as shown in Fig. 6, there will be little or no tendency for the kite to move. If now, however, the couple Z_0 has a finite value the kite will turn about an axis sensibly coincident with the string. This turning alters the attitude of the kite surfaces to the wind and results in a change of position. If slight motion of this sort does not cause the couple Z_0 to change its value the movements of turning and translation will, of course, go on. Now darting results when a considerable movement of translation must take place before the couple has vanished, but it so happens that at the point in the path of the kite at which the couple Z_0 vanishes the moving force M *has a finite value*, and the motion of translation continues without any rotation for a short time. A new value of Z_0 with opposite sign and a different attitude of the kite with respect to the wind, however, soon results and causes the kite to retrace its previous movements in a similar but opposite attitude. Thus is produced the continuous periodic movement we call darting. M and Z_0 in this case are never *simultaneously* inappreciable, which is the condition for steadiness.

A dive is the result of nearly the same condition of forces as a dart, except that at the turning point, M and Z_0 are nearly simultaneously zero. Dives often result from the sudden overthrow of equilibrium due to peculiar inequalities of the wind and temporary distortions of the figure of the kite. The dive becomes a gyration simply because the algebraic sign of Z_0 does not change throughout the entire evolution; if the kite does not attain the conditions corresponding to a steady position at one gyration, it follows that Z_0 is still finite and has the same algebraic sign and that further gyrations are inevitable. The radius of the gyratory orbit is wholly dependent upon the relation between the speed of rotation produced by the couple Z_0 and the velocity of translation under the force M. When M produces a considerable translation during the time that Z_0 turns the kite but a little, then the orbit of gyration will be one of great diameter. When the power of the couple to turn the kite is great the orbit of gyration will be small. In the special case of $M = 0$ gyration obviously reduces to the evolution we call *spinning*, in which M is sensibly zero, while Z_0 is considerable in magnitude and constant in algebraic sign.

Thus is fully explained, from the mechanical point of view, every conceivable movement that any kite restrained by a single line can execute, for any evolution must in character be within the movements classified and explained above.

Our discussion has throughout been a study of the action of certain specified forces, and the reader may use his own choice as to what particular kind of kite he conceives to be the origin of the forces in question. When the conditions among the forces we have specified exist, the evolutions we have described will be executed.

Use of two or more lines.—Very little need be added to the foregoing general explanation of the flight of kites to adapt it completely to the case of kites held in restraint by more than one string.

The three degrees of freedom of angular movement possible to a kite restrained by a single string were fully explained on page 145. Two strings attached at points either side of a fore and aft middle line prevent all sidewise tilting or careening of the kite, and hence only two degrees of freedom of angular motion remain, that is, the kite may still tip longitudinally and may rotate under the action of the couple Z_0. Even this latter freedom, however, is under some constraint, due to the fact that the system of parallel strings will resist

being twisted up to a certain point; that is, any tendency of the kite to turn in its own plane, or one sensibly agreeing therewith, will be opposed by a greater and greater resistance until the two strings become crossed, whereupon their efficacy to nullify the couple Z_0 practically vanishes. If a kite with two or more strings succeeds in executing one or two complete gyrations the strings will be twisted around each other, and much, if not all the efficacy of the system vanishes until the strings can be untwisted.

We have found that two flying lines not only may serve to suppress and prevent all lateral tilting of the kite surfaces, and place such movements under the control of an operator, but the strings also exert an opposition to free rotation of the kite under the action of the couple Z_0. This counter-couple action of the strings is not of sufficient power, in general, to completely nullify the couple Z_0 under all circumstances, but it is important to notice that it can contribute to this effect. With two strings the kite will, for these reasons, be more steady in its motions than with one.

We pointed out, on page 146, that in its *steady position* a kite must constantly vary its position and attitude with changes of the wind, and that a so-called "center of pressure," C, constantly shifts from point to point within the surface of the kite. Now, when two strings are used, as shown in Fig. 9, it is obvious that the action line of the resultant force, R_0, may take many different positions and still constantly pass through the line, $F'F''$, connecting the extremities of the two strings. All these changes of R_0 (and of the point C) can occur without any change whatever in the position of the kite, provided the *direction* of the force, R_0, remains *unchanged*. Changes within these limitations may often occur, and therein lies another reason why a kite with two strings will fly more steadily than with one.

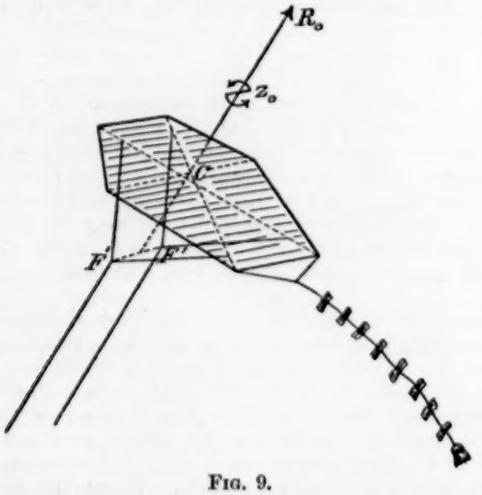

FIG. 9.

When three or more strings are employed only one degree of freedom of angular motion remains to the kite, namely, it may turn its head to one side or the other under the action of the couple Z_0, but even this, as already explained, is under some constraint from the strings. Furthermore, the action line of the resultant, R_0, may now take any position whatever, provided that it always passes within the figure which incloses the system of strings, and the kite will be under no necessity of changing its position, except in those cases and only to the extent that the force, R_0, *changes its direction*.

We thus see that the use of two or more strings properly applied renders changes in the position of a kite far less extensive than they are likely to be with a single string. While the greatest possible degree of *stability* is thus obtained, yet the *steadiness* with which the kite flies will depend, as always, upon the control that is exercised upon the couple Z_0. No matter how *stable* the equilibrium may be, if the couple Z_0 can acquire appreciable finite values the kite is likely to fly in a restless, unsteady manner. For the distinction between the words "stability" and "steadiness," as here used, consult page 153.

The efficacy of dual or triple strings depends wholly upon their not crossing each other. With long, deeply sagging strings necessarily under different degrees of tension it becomes impracticable to prevent crossing, and their use is feasible only in special cases and under considerable tension.

VIII.—EFFECTS OF CHANGES IN WIND AND POSITION OF KITE.

In order to discuss completely the conditions which can contribute to the equilibrium of a kite, it is necessary to understand thoroughly the character of the changes which take place in the systems of applied forces when the kite changes its position or when variations arise in the force or direction of the wind. In this study we must consider both the force, R_0, and the couple, Z_0.

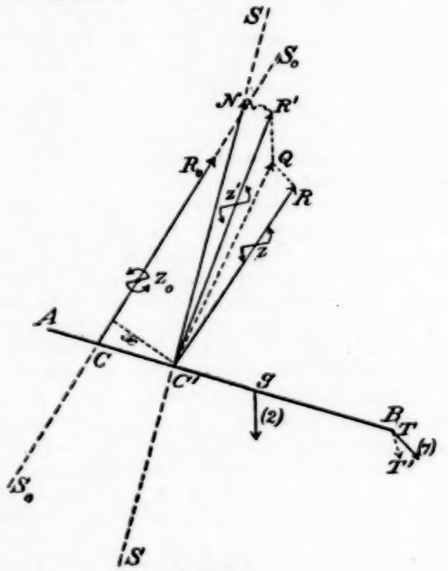

FIG. 10.

Relation of forces.—The relations which the force R_0 bears to the primary forces of wind, gravity, and action of the tail have been fully set forth on pages 142–144. These may be briefly shown again, as follows: If $S\,S$, Fig. 10, is the *central axis* of that important system of forces due to the pressure of the wind upon the *sustaining surfaces* of any kite and C' an assumed point of application of the equivalent force, N, of the system, then the total pressure of the wind upon the entire kite structure, excluding the tail, will be equivalent to and may be represented by a force R' and a couple Z', as shown; the former acting through C', but inclined to N at a slight angle. Again, the total effect of all the forces of wind, gravity, and tail will be equivalent to a couple Z and a single force represented by the line R, also acting through C'. Finally, by resolving the couple Z into components with axes respectively parallel and perpendicular to the force R, and then combining the perpendicular component with R, we get the force R_0 parallel and equal to R, but at a greater or less distance from it. We also get the couple Z_0, whose forces act in a plane perpendicular to R_0. These resultants represent the total effect of all the forces acting upon the kite. The force R_0 coincides with the *central axis*, $S_0\,S_0$, of the whole system of forces. It is possible, but exceedingly improbable, that in actual kites the forces N, R, R, and R_0 may all fall

within one and the same plane. We will consider, however, only the more general case, that the forces are in different planes.

To assist in the further study of the results of changes in the forces, we have added to the diagram the line $A\,B$ and the forces (2) and (7) of gravity and the tail, respectively. The line $A\,B$ represents simply an edge view of a reference plane parallel, for example, to the longitudinal axis of the kite. It may also be imagined to represent an edge view from the side of a single flat-surface kite. The diagram is, however, representative of any kind of kite if we regard $A\,B$ as simply a reference plane. The point C', the center of gravity, g, and the point of attachment, T, of the tail are, for simplicity, all supposed to fall within this plane, but this is not essential. If A is the forward portion of the kite, then C will be nearer A than g; at least, this is a more favorable relation than otherwise for the most satisfactory flight, as will more fully appear hereafter.

Having thus before us a clear picture of the relations between R_0 and the forces of wind and gravity, we may formulate the changes in R_0 corresponding to variations of the wind and alterations in the position of the kite, as follows:

Variations of wind force.—Mere changes in the force of the wind will have little other effect than simply to alter the magnitude of the force N without changing either the position or the direction of the central axis $S\,S$. Furthermore, the force R' will experience a proportionate change of magnitude, but without any important change in direction. These results will follow *moderate* changes in mere wind force, because, from what is known of the laws of wind pressure, its effects upon the surfaces of the kite, the framework, edges, etc., and even the effects of waves and eddies, are, for slight changes, all proportional to the *same power* of the wind velocity. For considerable changes of velocity the *eddy* and *wave* effects may possibly vary at a higher power of the velocity than simple pressure effects, and if pronounced waves and eddies are present in a given kite, then the direction of the force R' will probably deviate from the direction of N by greater and greater amounts with higher and higher velocities. Such kites are actually blown down and fly lower with very strong winds.

The force (7) due to the tail is partly a wind effect, and for an increase of velocity (7) will be both increased in magnitude and its direction made more nearly horizontal, and *vice versa*.

The weight of the kite (2) is constant, and obviously it follows from the above that even if the force R' changes only in magnitude with variations of wind force, the total resultant R will, in general, take a more horizontal direction and diminish in magnitude with a falling off in wind force, whereas, with increased wind velocity, the resultant R will be greater in magnitude and deviate less from R'.

R_0 is always equal and parallel to R, but the distance, x, between them depends upon the couple Z. We will refer to the variations of x presently.

Variations of the couple Z.—It will be remembered that the couple Z is the total resultant couple of the whole system of forces when that system is reduced to the force R acting through C'. The existence of this couple results principally from the action of the forces of gravity (2) and of the tail (7), but there is also included in Z a small and very important couple effect, resulting from the action of all the wind forces. These form such a complex system of elementary pressures, acting at every conceivable point of the kite, that it is utterly impracticable to produce that exact condition of symmetry required in order that the resultant couple of so complex a system shall necessarily be zero. Or, rather this is only possible by the introduction of certain forces which automatically control the values of Z_0. While this small couple effect is included in Z, yet all the variations of Z that are of importance from the present standpoint depend upon the moments of the forces (2) and (7) about the point, C', which, as we have found above, is not changed in position by a mere change of wind force, *per se*. It follows from this latter circumstance and the constant magnitude of (2) that the moment of the force of gravity remains constant under changes of wind force as long as the kite holds its position. The couple Z will, therefore, also be sensibly constant, provided the kite has no tail. With a tail, the important variations of the couple Z result from changes in the action of the tail corresponding to changes in the force of the wind. Methods of determining, once for all, the magnitude and direction of action of the tail force (7) were fully described at page 141. If the action of gravity on the tail is very small as compared with the wind effects, then the changes of the force (7) will be mostly changes in magnitude, the direction of action of the tail remaining nearly constant and nearly horizontal, except for the very lightest winds. If, however, the weight of the tail is relatively considerable, then the direction of action of the force (7) will change considerably with different intensities of the wind.

It results from the foregoing that the values of the couple Z, corresponding to the possible values of the tail force (7), may vary considerably with mere changes of wind force; thus, when the action line of (7) passes through C' the moment is zero; if the tail blows out horizontally the action line in general will pass below C', and the moment will then have the opposite algebraic sign from the moment due to gravity acting at g; while with the tail in the position shown in the figure, its moment and that of gravity have the same sign. We, therefore, see that, in general, even slight changes in the wind force alone can give rise to considerable and important changes in the couple Z.

We are now prepared to consider further how changes in the couple Z affect the force R_0. When Z is resolved into two components, Z_0 and Z_1, of which the latter is combined with the force R, in the manner already explained on page 144, we get the force R_0, the position of which will be forward of R; that is, nearer the A end of the kite than R. This is necessary because the moment of R_0 about an axis through the point C', perpendicular to R, must be equivalent to the couple Z_1. The perpendicular distance, x, between R_0 and R must, moreover, be $x = Z_1 \div R$. Even supposing now that Z remains constant under variations of wind force (and this can be the case with the tailless kites) it is obvious that x varies inversely with R. When Z is not approximately constant its values, in general, will tend to increase, rather than otherwise, with diminution of wind force, because the force (7) then takes a more nearly vertical direction, as shown at $T\,T'$, tending, on account of the rapid increase of leverage, to produce a greater moment about the point C than before. The combination of circumstances that can cause the couple, Z to diminish when the wind force diminishes is an improbable and therefore not an important or general combination for our present purposes. From the foregoing it results that, in general, when the wind force diminishes, not only does the resultant R_0 diminish in magnitude and change the inclination of its action line, but the whole axis, $S_0\,S_0$, shifts to a new position nearer the forward end of the kite.

To avoid confusion the distance x is greatly exaggerated in the figure. R_0, in general, is a very large force compared with (2) and (7), and as a result the numerical value of x and its variations will be small, except in very light winds.

It must be noticed that thus far we have considered only the changes that take place instantly in the relations between the forces whenever the force of the wind changes. The kite itself it still supposed to retain its original position.

Résumé of results.—Briefly stated, what happens among the

forces acting upon a kite when the wind pressure changes is this: (1) The pressure N upon the sustaining surfaces simply changes magnitude, but retains sensibly its original action line and position; (2) The total resultant R_0 not only changes in magnitude directly with the wind force, but when the wind force diminishes its direction deviates more from the vertical and its position shifts toward the forward end of the kite, and *vice versa*. Finally, the couple Z_0, which is sensibly zero when equilibrium prevails, in general will not necessarily undergo any important change. The couple may take on a small value which may be either positive or negative, or it may remain zero. Any one of these results may occur in special cases, and even in the same kite under diverse circumstances.

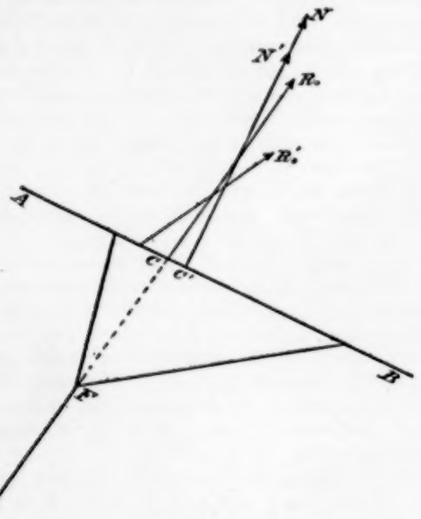

FIG. 11.

Fig. 11 shows diagrammatically the relation of the forces C', N, and R_0 with the kite in equilibrium under the restraint of the string acting through the point F. A reduction in the wind force gives rise to the condition shown by the forces C', N', and R_0', which are no longer in equilibrium with the pull of the string. Before we discuss the motions that must ensue let us first follow the effects of a change in *direction* of the wind.

Variations of wind direction.—Any change in the direction of the lines of flow of the air, whether to the right or left, or in their upward or downward trend, has the same effect upon the wind forces as if the wind were constant and the attitude of the kite had changed in a corresponding manner. These effects are identical only to the extent of the wind forces; the gravitation and tail effects will be changed in relation to the other forces if the attitude of the kite is changed. Any change whatever in the direction of the wind is accompanied by such an alteration of the system of wind forces acting upon the sustaining surfaces of the kite that the *central axis* S S of that system changes its position, and possibly its direction, depending upon the nature of the kite. If the kite contains but a single flat plane, the axis S S will remain sensibly parallel to its original direction, but, in general, with kites whose surfaces are more or less curved the axis will not only shift its position, but will change slightly its direction at the same time. If the change in wind direction is wholly confined to a vertical plane, the point C', Fig. 11, will move toward the *forward end* of the kite when the angle of incidence of the wind upon the surfaces *diminishes*, and *vice versa*. If the change is in the azimuth of the wind the point C' will, in general, shift laterally as well as forward or backward. In kites having automatic lateral stability (page 154) the point C' must always remain very nearly at least in a certain longitudinal line, as explained more fully hereafter. We find, therefore, that with a change of wind direction, not only must the axis S S shift its position and, in general, change its direction slightly, but the magnitude of the force N increases and decreases according as the angle of incidence of the wind upon the sustaining surfaces is increased or diminished by the change in direction. The distance that the point C' will move for a given change of incidence of the wind can be computed in certain cases by Lord Rayleigh's formula, equation (2), page 140. Its applicability, however, is exceedingly limited and restricted to single, narrow, rectangular, plane surfaces presented to the wind in a special manner. The formula is utterly inapplicable to the general case of kites. Similarly, the relative magnitude of the force N corresponding to a certain incidence can, under certain conditions, be computed by Duchemin's formula, but in this case, likewise, the proper application of the equation is so exceedingly limited as to be of little practical use in the present connection. There does not seem to be any thoroughly complete data available by which to determine, *a priori*, the exact changes in the position of C' or in the direction and magnitude of N corresponding to changes in the incidence of the wind.

We have already shown fully the effects on R_0 of a change in wind force. Not only will these results follow when the wind changes its direction, but there will be added to them similar and additional effects resulting from the movement of the point C' and the change in the direction of N. Moreover, important secondary effects will arise from the pressure of the wind represented by the series of disturbing forces we have designated e, f, n, v, and w. Especially is n, the pressure upon the neutral surfaces when present, likely to experience very considerable changes. The tail, also, will be blown off in a different direction, and while the force (7) may retain the same numerical magnitude, the *moment* of the force may change very greatly and in such a manner that the couple Z_0, which is sensibly zero when the kite is in equilibrium, takes on a considerable plus or minus value, especially if the wind has changed its direction in azimuth.

Following a line of reasoning similar to that employed on page 149 in establishing the effects on the couple Z and the distance x, resulting from a change in wind *force*, it may be shown that with a change of wind *direction*, R_0 will be changed in magnitude, direction, and distance, x, from the force R, which itself shifts its position. If the incidence of the wind

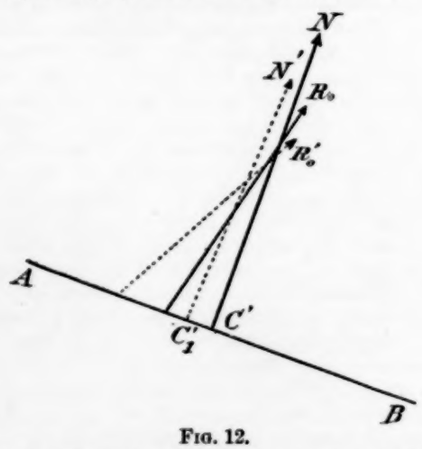

FIG. 12.

upon the kite surfaces is *smaller* as a result of the change in wind direction, then R_0 will become *smaller* and both R_0 and the point C' will move *toward* the front edge of the kite to such positions, for example, as shown at R_0' and C_1', Fig. 12.

Except for the changes in Z_0, these effects are identical in general character with those which result from a *diminution in wind force*. Similarly, a change in *direction* which causes the incidence of the wind upon the surface to *increase* can be shown to produce changes in R_0, which are similar to those resulting from an *increase* of wind force. The tendency of the kite in the two cases to move will, however, be entirely different because the couple Z_0 is but little affected by a mere change of *force*, but may be greatly affected by a change of *direction*. It must not be forgotten that the several forces shown in the diagrams 10, 11, and 12 are not necessarily in the same, or even in parallel planes. If R_0 is in the plane of the diagram, then the other forces are in all probability not in that plane nor parallel thereto. It is not even probable that R_0 is in the plane of the diagram, because in that case the force would be in a plane perpendicular to the reference plane $A\ B$, and this could be the case under only the most perfect conditions of symmetry of the kite.

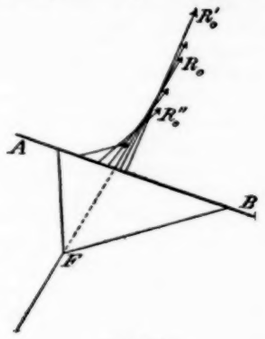

FIG. 13.

We have now fully set forth the general character of the changes in the resultant force R_0 and the couple Z_0, corresponding to changes of either the force or direction of the wind. These results may be shown graphically, as in Fig. 13, in which the force R_0 is shown directly in line with the kite string passing through the point F. The kite is, therefore, in equilibrium. Several lines, R'_0, R''_0, etc., show other possible values of the resultant force R_0 such as may logically arise from changes of the wind. While the disparity between these forces is exaggerated for the sake of clearness of the diagram, yet nothing impossible is there shown, and it must be remembered that no two of these forces need necessarily be in the same plane. Moreover, these are momentary states of the resultant R_0, corresponding to sudden changes of the wind and obtain only until a change takes place in the position of the kite. The important feature brought out by our analysis, and to be noticed here, is that when the magnitude of the resultant R_0 *diminishes* its action line takes a more forward position and a direction more inclined *from* the vertical. On the other hand the opposite effects ensue when the magnitude of R_0 increases. Special cases may arise where simultaneous changes of both *direction* and *force* may tend to compensate and offset each other, respectively; but these are rare and unimportant and not general effects.

The ability of a kite to recover its equilibrium when disturbed by a change of wind conditions producing results such as shown in Fig. 13 depends upon the ability of the kite string to align itself with the resultant R_0, whatever be the position and direction it may assume. Now, no two of the possible values of R_0 necessarily pass through a common point. In Fig. 13 there seems to be a tendency for the forces to cross each other behind the line $A\ B$, but when we remember that these forces are not necessarily in the same plane, we see that it is improbable that even any two of the forces intersect. Since the action line of the force exerted in the kite string must always pass through the point F, where the string is made fast to the kite, it is obvious that no matter how the string may change its relations to the kite (which we still consider to remain fixed in position), or how the bridle may be arranged, it is impossible for the string, being in alignment with one value of R_0, to align itself with any other value, except on rare and improbable occasions, such as referred to above. These results will follow under the condition that the position of the kite remains fixed, and it is important that they be fully recognized. Thus, if a kite were fixed in mid-air so that it could not change its position, a string could be tied to the kite in such a way that the string alone, without assistance from other means, could neutralize the action of the resultant force R_0 for *one particular value* only, but no matter how the lower end of the string were shifted about, if still fastened to the same point at the kite end, it would, in general, be impossible for the string to neutralize any other than one value of R_0 depending upon one condition of the wind. We thus see that mere changes in the angular relations between the kite and its string tied at a given point, F, are, in general, each and all inadequate to reestablish an equilibrium that has been disturbed by changes in the conditions of the wind. Only by a complete change in the attitude of the kite to the wind can equilibrium be again established.

Changes in attitude of the kite.—Whenever a state of equilibrium is disturbed by any cause and in such a manner that the resultant force is *diminished*, the action line will, as we have shown above, make a *smaller* angle with the general plane of the kite and its position will be farther forward, as shown in Fig. 14, in which R_0 is the resultant before and R'_0 that after the equilibrium is disturbed; the gravity (2) and the tail force (7) are also shown.

If the string is attached at F then the kite will be moved in the direction indicated by the force at M, which can be fully determined by the methods already described on page 145. The force M in this case and the motions that ensue are of such a nature that the kite in its onward movement assumes a greater angle of incidence to the wind. This causes the resultant pressure of the wind upon the sustaining surfaces to increase and, as a further effect of the increase of the angle of incidence, the point of application of this force at C'_1 moves away from the front edge of the kite to such a position as C'_2, Fig. 15, which is supposed to represent the kite *after* it has moved to some new position and has changed its incidence to the wind. The pressure of the wind upon the sustaining surfaces before moving and after equilibrium was disturbed is shown at $C'_1\ N'$. The pressure after the kite has moved to its present position will be represented by a line, $C'_2\ N''$, nearly parallel to $C'_1\ N'$ but farther from the front

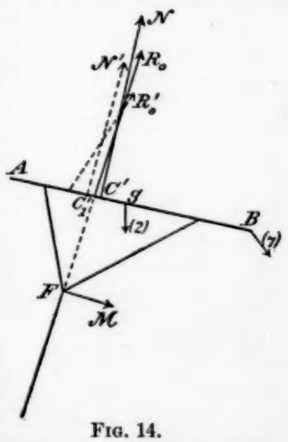

FIG. 14.

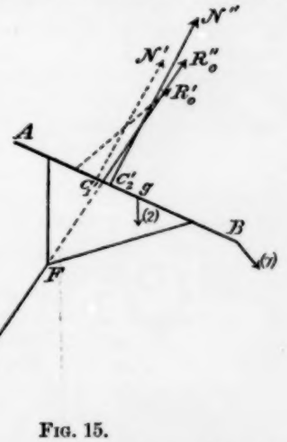

FIG. 15.

edge of the kite. The forces C'_1, N', and R'_0, in Fig. 15, are shown in their original relation to the reference plane $A\ B$. The absolute direction of these forces in the first or original position of the kite was, of course, more nearly vertical.

The change in the position of the kite effects the following changes in the relations of forces:

(*a*) The pressure of the wind upon the sustaining surfaces is increased in magnitude and its action line cuts the reference plane $A\ B$ at a point, C'_2, farther from the front edge of the kite, and, in general, C'_2 will be nearer the center of gravity, g, of the kite.

(*b*) The forces (2) and (7), after the change in position, will be parallel and equal to their status before the change.

(*c*) In consequence of (*b*) and the shorter distance between C'_2 and g, the moments of the forces (2) and (7) will be smaller than before the change of position.

(*d*) Finally, as a general result of all the foregoing alterations the total resultant R''_0 will be greater in magnitude, its direction will be more nearly at right angles to the reference plane $A\ B$, and its position will be farther from the front edge of the kite than that of the force R'_0, which is the state of the total resultant just after the equilibrium was disturbed and before the kite changed its position.

A similar line of reasoning may be employed to bring out the exactly opposite results that ensue when the equilibrium has been disturbed, because the resultant R'_0, Fig. 14, has a *greater* value than R_0.

It follows, as a natural consequence of the above results, that when the string is tied to the kite at some point, F, in *front* of, that is, on the *windward* side of the kite, the force M, whenever it has finite values, will tend to move the kite to a position in which the string and the total resultant R''_0 will exactly align with each other, as shown in Fig. 15.

Referring again to Fig. 13 it was shown in connection therewith that as long as the kite retained a fixed position the possible values of the total resultant R_0 were in such relation to each other that no two values could be neutralized by the string when attached to the kite at a single point, F. When, however, we permit the kite to move and change its attitude to the wind and consequently its relation to the action line of gravity and the tail force, it is possible to find such a position of the kite corresponding to each possible force and direction of the wind that the resultant will always pass through the point F.

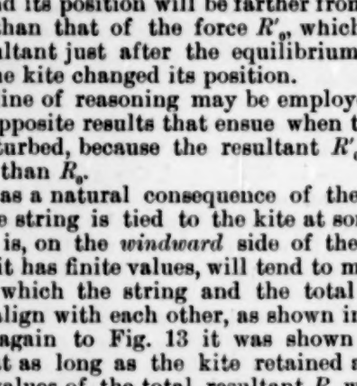

FIG. 16.

Fig. 16 shows numerous values of the total resultant R_0 each corresponding to a certain force of the wind and a certain position of the kite. In the figure we can conveniently show the kite only in one position. The forces are, therefore, shown only in their relation to the reference plane of the kite, and we must imagine the kite to take as many different positions as there are forces shown, each for each. For each force and for each position the string can align itself with the force, and thus neutralize it, because all the forces are shown passing through the common point F. These forces are not necessarily confined to one plane. The whole problem of the ability of a string to neutralize the total resultant of all the forces of wind and gravity acting upon a kite depends upon the circumstance that a relation, such as shown in Fig. 16, is possible between the values that the total resultant R_0 can assume, no matter what the changes in conditions may be. The analysis is not limited to those circumstances that must prevail when the kite must fly upward or else dash itself against the ground, but finds its full application in the case of a kite string fixed to a point high up in the free air, in which case the kite can assume without interference any position the forces impose upon it.

We have thus fully set forth the general character of the changes among the forces acting upon any kite corresponding to such changes as may occur in the wind effects. The general conditions under which equilibrium may be established have also been shown.

Center of pressure.—We have already taken occasion to point out the indefinite, unphilosophical character of the expression "center of pressure" as applied to wind pressures upon kites. The idea that the "center of pressure" is a tangible conception is so generally prevalent that a few additional remarks upon the same subject may not be amiss. The sustaining surfaces of a kite are the origin and generating cause of the principal wind pressures acting upon the structure. When these surfaces are simple and consist of but a single plane, as indicated in Fig. 6, and if we think of the pressures upon this surface only, we may logically imagine all the elementary pressures concentrated and acting at a single point, as at C', which we may then regard as "*a center of pressure.*" The point, however, as we have shown, has no other mechanical significance than that it is an assumed point on the *central axis* of that system of pressures which act upon the *sustaining surfaces.* If any or all of the small disturbing forces which we have designated e, f, n, etc., have finite values, then some other point, C'', not shown, will be "*a center of pressure*" for all the wind forces upon the whole kite. Again, if we include in our thought the attraction of gravity and the pull of a possible tail among the forces acting upon the kite, then another point, C, not necessarily coincident with either C' or C'', becomes "*a center of pressure,*" or, more logically, a center of *forces.* Finally, when the structure of the kite is complex, with superposed and separated supporting surfaces, we are quite unable any longer to follow out the analogy of a center of pressure or assign its location.

If the "center of pressure" of all the forces acting upon the kite is the desideratum, then it is the point C, for example, in Fig. 6, or it is any one of the points in Fig. 13 where the forces R_0 intersect the reference plane $A\ B$, or it may be any one of the points in Fig. 16 where the forces there shown intersect a reference plane which may be chosen anywhere at random. None of these points can logically be designated as centers of *pressure* because they depend upon the action of the tail of the kite, and upon gravity quite as much as upon wind pressure. The nearest approach to a center of pressure is the point we have designated C', C'_1, C'_2, etc., Figs. 6, 10, 11, 12, 14, and 15, but even this is nothing but an assumed point of action of the resultant pressure upon the *sustaining surfaces.* If any one point of the kite is worthy of a special name on account of the distinctive properties possessed by it, then it should be the point F, whose properties are those of a real *center of forces;* that is, a point through which resultant forces constantly act. This is seen in Fig. 16. In another sense, however, F is simply a point of support of a body subjected to forces acting in an upward direction.

IX.—CONDITIONS OF STABILITY AND STEADINESS OF KITES.

Before we attempt to show how to impart stability to a kite, that is to establish in general those conditions that will enable the kite to maintain its equilibrium under variations of the wind and changes in the position of the kite, it is important to clearly point out upon what *stability* depends and show when the terms *stability* and *steadiness* may have distinct applications.

When employed in the technical sense, *stability* has reference to a state of *stable* equilibrium, and, as is well known, the equilibrium of a body is *stable* whenever, if displaced from its condition of rest, the body tends to resume its original attitude. When we deal with the equilibrium of ordinary objects supported against gravity, or of vessels floating upon liquids, or of objects sustained in the air, as in the case of balloons, for example, the whole quality of stability results whenever a certain relation is established between two forces, namely, the force of gravity acting at the center of gravity of the body and the resultant of the system of supporting forces. This relation is such that the applied forces will always restore a displaced body to its original attitude, whenever the disturbing cause is removed or will automatically establish a new position of equilibrium when natural changes occur in the system of applied forces. The case, however, is very different when we consider the equilibrium of a kite. Here, as has been fully shown in the preceding pages, we must deal with two separate and distinct conditions of equilibrium, that is, not only must the restraining pull of the string, which is the supporting force, neutralize exactly the resultant R_0 of the complex system of the applied forces, but the resultant couple Z_0 of that system must also be zero at the same time. The entire independence of these two conditions of equilibrium must be fully recognized. All the kite string can do toward bringing about a condition of equilibrium is to neutralize the force R_0. Except for the very feeble and wholly insufficient resistance it may offer to being twisted or untwisted, the string is utterly powerless to oppose, in any way, the action of the couple Z_0, which, when the kite is otherwise in equilibrium, tends to produce rotation around the string as an axis. It therefore happens, in the case of a kite, that we may establish between the string and the resultant R_0 all those relations that in ordinary cases are sufficient for a state of stable equilibrium, but the kite may, nevertheless, dart about in the most restless and erratic manner imaginable, simply because the couple Z_0 may have finite values when R_0 is neutralized, and *vice versa*. We thus observe that the two conditions essential to the equilibrium of kites give rise to two independent sets of conditions that must be separately established to produce stability. One of these is the set of conditions, in consequence of which the string can neutralize the resultant force R_0 under all variations of the wind and changes in the position of the kite. The other is the set of conditions that must be provided in every kite, and by virtue of which the couple Z_0, whenever it temporarily acquires finite values because of changes in either the wind or the position of the kite, is immediately reduced to zero in consequence of the incipient rotation resulting from its own action.

The complete stability of the kite results only when both the above mentioned sets of conditions are fully established. Even under these circumstances, and notwithstanding that its equilibrium is perfectly stable in every detail, the kite may not poise in that comparatively motionless manner which the word *stability*, when applied to kites, is intended to imply. This paradoxical result will arise whenever the force R_0 is neutralized with the kite in one position while the couple Z_0 becomes zero only with the kite in a different position. The kite will then execute those rythmical, periodic, pendulous movements already referred to in the paragraphs on darting on page 147.

Hereafter, therefore, if a kite poises in a nearly motionless attitude we shall say that it flies *steadily*, or that it is steady. On the other hand, it will be an *unsteady* kite if it constantly shifts about in a pronounced and restless manner.

It should be noticed that if the words are used in strict accord with their technical meaning, the slightest disturbance will completely overthrow the equilibrium if it is *unstable*, and an unstable kite would be wholly unable to fly at all. If, however, its equilibrium is *stable* the kite is bound to fly somehow, and it will fly steadily whenever the wind is steady and the force R_0 and the couple Z_0 are simultaneously neutralized.

An important step is taken toward reaching a clear understanding of how to control the flight of kites when the two independent conditions for which *stability* must be established are thoroughly differentiated and when the distinction between *stability* and *steadiness* is recognized.

We need very badly two good words that shall be descriptive of the two independent sets of conditions by virtue of which stability results. In the one case stability is established wholly with respect to the action of the resultant force R_0, and in the other with respect to the couple Z_0. Recognizing that R_0 tends to produce translation only and that the couple Z_0 produces only rotation, the expressions, *translational stability* and *rotational stability*, suggest themselves, and, in the absence of better terms, these will be used.

Translational stability.—Under this topic we shall discuss simply those conditions which will produce states of stable equilibrium with respect to the action of the resultant force R_0.

Whatever the force or direction of the wind may be there is always a corresponding position and attitude of the kite in which the total resultant R_0 of all the forces acting upon it will pass through a point F, Fig. 16, at a greater or less distance in front of the kite surfaces. F may have many different positions with respect to the kite, each giving rise to its own corresponding positions of steady flight.

We have already fully shown that whenever the point F is at some distance in front of the surfaces of a kite the action of the forces when not in equilibrium will always tend to move the kite into a position and attitude in which the resultant force R_0 is fully neutralized by the action of the string. This being the case, the equilibrium of the kite with respect to the force R_0 is, therefore, *stable;* that is, a condition of *translational stability* is established simply by giving the point F a position well in front of the kite surfaces. On the other hand, the equilibrium will be *unstable* when F is near to or behind the kite surfaces. A true state of neutral equilibrium is not possible in the case of a kite. As the point F approaches nearer and nearer to the surface of a single plane kite the equilibrium presently becomes only partly stable; that is, the equilibrium is *stable* for some conditions, but *unstable* for others; whereas, when F is quite behind the kite as a whole, the equilibrium is *unstable* for *all* conditions.

Considering only the resultant force R_0 of the system of forces acting upon a kite, we may therefore say that the *stability* of the kite is assured whenever the point F (which may be defined to be the point at which the string ends and the kite actually begins) is fixed, or at least constrained, in reference to the kite structure and is in front of the kite.

Stability with bridles of different types.—The manner of attaching the string to the kite, therefore, wholly determines whether the translational equilibrium will be *stable* or not. In a single surface kite F must be in front of that surface, but it need not necessarily bear a fixed relation to that surface. In kites with superposed surfaces F may be within or even behind the lowermost surfaces without wholly impairing

the quality of stability. In these cases an actual bridle may not be employed at all, but the string may be fastened directly to some stick of the kite, and the point F will then, in general, bear a fixed relation to the kite structure. Most other methods of attaching the string are generally reducible to a condition that the point F is free to move in a circular arc, the plane of which is perpendicular to a line which itself bears a fixed relation to the kite and also contains the center of the arc. The bridle on a malay kite is a typical bridle answering these conditions, but obviously other forms are possible. In whatever manner the string may be fastened to the kite the point F is either fixed in reference to the structure, or it is permitted to move in relation thereto only in some constrained manner. Peculiar and rather complex cases of constraint arise in the case of the use of dual and triple strings. Different methods of bridling and restraining the kite give rise to different conditions under which stability is possible. The conditions of stability and equilibrium with dual and triple restraining lines were presented on page 145. Other cases are briefly discussed as follows:

(*a*) *When F is a fixed point.*—When the string is tied to a fixed point of the framework, as may be the case in cellular kites, or to bridles such as shown in Fig. 6, then, as we have found, the equilibrium will be *stable*, because a reasonable disturbance of the relation of the forces is accompanied by a tendency to restore equilibrium. In the case of the kite this tendency may be nullified and made ineffectual because of the presence of a disturbing couple, but the equilibrium is of a *stable* character nevertheless.

(*b*) *When F is not a fixed point.*—When a bridle is made of a single bight of string, the point F will no longer bear a fixed relation to the kite, but will be free to move in a circular arc, as described above. For the equilibrium of the kite to be *stable* under these circumstances, it is necessary that the central axis of the whole system of forces shall always pass through the fixed line joining the extremities of the bridle and fall between those extremities. This will be understood from Fig. 17. The bridle is fastened at A B and the string at

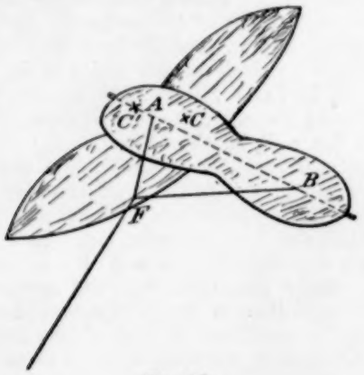

FIG. 17.

F. If the *central axis* of the system of forces passes at one side of the line A B, as, for example, at C, or beyond either extremity of that line, even if on the line, as at C', then it is impossible for the kite to assume a flying attitude, simply because the action line of the string can not pass through the point C or C', as is necessary for equilibrium.

In order that a kite with a bridle of this type may fly at all, it is necessary to employ some artifice that will cause the central axis of the whole system of forces to always pass through the line A B and within its extremities. We will discuss more fully the nature of such an artifice in the next paragraph. This essential condition being established and the point F being in front of the kite, then, as before, the equilibrium will be *stable*, because the forces will both move the kite and alter its attitude to the wind until the string and the resultant force R_0 come into alignment, and thus produce equilibrium.

That quality of the kite by virtue of which the resultant force R_0 is made to always pass through the line A B, joining the extremities of the bridle, is generally known as its *lateral stability*.

The lateral stability becomes a question that requires separate consideration only when bridles are employed which do not restrain the point F laterally. When F is rigidly fixed in reference to the kite structure, then both *lateral* and *longitudinal stability* are equally provided for. Whenever F is fixed in only a longitudinal sense, as in the present case, then *longitudinal* but not *lateral* stability is assured.

If it were customary to bridle a kite with a single bight of string having its two ends made fast to the framework at two lateral points, then we would need to separately consider *longitudinal stability*. This, however, is not the case, and we will only remark further in this connection that both lateral and longitudinal stability are simply component parts which together make up that quality which we have called *translational stability*.

A simple and comparatively effectual method of securing lateral stability in single surface kites is to dispose the lateral halves of the kite in such a manner that the surfaces form a dihedral angle with each other. In this case, when one side temporarily receives a greater pressure than its fellow the kite is tilted laterally, and the side moves into a position of less inclination to the wind, the intensity of pressure thereon being thus diminished, whereas, the opposite side is placed by the tilting in an attitude of greater inclination to the wind and receives a corresponding increase of pressure. A balance between the opposing forces on the lateral halves of the kite is thus preserved. In the malay, Eddy, and many different forms of oriental kites the dihedral angle is produced mostly by springing the cross stick or sticks of the kite into a bow of slight depth with the convexity presented to the wind. The slight angle thus made possible between the lateral halves of the kite is, however, in general, made more effectual by the bagging of the covering, which is often intentionally fitted somewhat loosely. In many cases the cross sticks are not originally bowed, but are sufficiently flexible to bend when strained by the wind, and thus form the necessary dihedral angle.

Even at the best kites of this type can acquire by means of the dihedral angle resulting from the bowed cross stick and the loosely fitted covering only slight degrees of lateral stability. The idea is current with some that flexible, yielding frames, *per se*, give rise to remarkable degrees of stability. This is, however, hardly the case. It is true that the stability of a flat, or nearly flat surface, will be greater, provided the lateral halves of the surface when strained can bend backward. The increased stability, however, never results from the mere yielding of the surface under strain, but comes about wholly from the dihedral angle effect made possible by the bending. If the surface were originally made rigid and of the exact form assumed by the bent pliable surface then the stability of the two would be exactly the same with the further advantage in favor of the rigid surface that when the force of the wind falls off and the bent surface relaxes, it loses part, at least, of its stability, while that of the rigid form is fully preserved. In any case, all kites which depend upon such expedients for lateral stability are only slightly stable flyers. Vastly better methods of contributing stability are well known and will be mentioned farther on.

The mechanics of lateral stability is readily understood from Fig. 18. Let B D, at (*a*), Fig. 18, represent an edge view

from the front of a kite composed of but a single plane surface. Let the two extremities of the bridle be tied at points A A', both represented at A, one of the points being directly behind the other. We may, therefore, regard A as the end view of a longitudinal axis about which the kite is perfectly free to tilt laterally. A slight inequality in the amount of surface in the lateral halves of the kite, or a temporary intensity of pressure of the wind upon one half greater than on the other will cause the resultant R_0 of all the forces to act through a point C at one side of A. The force R_0, therefore,

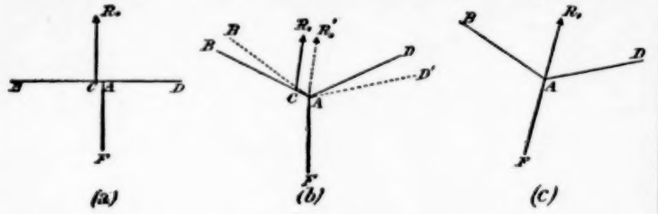

FIG. 18.

acts upon a short lever arm, C A, and tends to rotate the kite around A as an axis. Any tilting of a plane surface in a *strictly lateral* sense, that is, about an axis such as A, which is considered to be in a plane parallel to the lines of flow of the wind—any such tilting affects all parts of the surface alike, and the resultant force R_0 will continue to act through sensibly the same point, C, whatever the position of the plane may be. Lateral stability of a perfectly flat surface supported in the manner now supposed is, in fact, impossible. If, however, the lateral surfaces are inclined to each other, so as to form a slight dihedral angle, as at (b), Fig. 18, then, whenever the resultant R_0 acts at some point C not in the axis A, the force R_0 will still tend to rotate the surfaces about A, as before, but, when the surfaces have moved to some new position, as shown by the dotted lines, the portion B A will have a less and A D a greater inclination to the wind than previously, and in consequence, there is always some attitude of the surfaces in which the resultant R_0 will pass through the axis A. In the meantime, or subsequently, the kite, as a whole, will be translated to a position as shown at (c), Fig. 18, where the plane of the bridle, A F, contains also the force R_0, one condition essential to equilibrium. Other means than the dihedral angle may be resorted to for the purpose of producing lateral stability. Some are indicated in Fig. 19, (a) to (g).

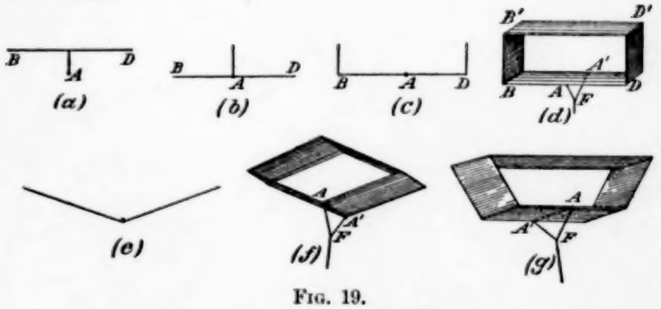

FIG. 19.

Surfaces set edgewise to the wind, but perpendicular to the sustaining surfaces, have been called "neutral surfaces" in the preceding pages. These, in general, contribute lateral stability as well as serve other functions. At (a), Fig. 19, we have shown a sort of keel attached to the sustaining plane B D. Under normal conditions the pressures on the opposite sides of such surfaces will be equal, but if the structure is tilted about a longitudinal axis, as at A, then one side of the neutral surface begins to experience an excess of pressure that tends to oppose the tilting, and a condition of attitude of the surfaces will, in general, be possible in which the *central axis* of the entire system of forces passes through the axis of support A A'. There is no essential difference in the mechanics of the question for the case in which the neutral surface is made in the form of a dorsal fin, as shown at (b). Similarly, neutral surfaces at the sides of the supporting plane B D, as shown at (c), also contribute lateral stability, and the addition of a single surface, B' D', as shown at (d), produces one of Hargrave's rectangular cells. It is not at all remarkable that the cellular kites should be so very stable when we notice the relatively great extent of neutral surfaces in a cell and compare the considerable power of resistance these surfaces can offer to lateral tilting of the kite with the corresponding feeble opposition possible in the case of a very flat dihedral angle or the even slighter resistance possible in those kites which depend upon the uncertain pliability of lateral wings. It is but a single step from the dihedral angle at (e) to the diamond cell at (f), and the trapezoid at (g) is another obvious combination, which, by the way, possesses remarkable stability. Each of these forms possesses the quality of lateral stability, because whenever the resultant force R_0 does not act through the longitudinal axis of support, as A A' in (d), (f), (g), Fig. 19, the kite will be tilted and a new force called into action, which, with a certain amount of tilting, will be just sufficient to restore equilibrium; that is, to cause the total resultant of all the forces to pass through the axis of support, A A'. A single cell, bridled in the manner shown at (d), in steady winds is a perfectly stable structure, both laterally and fore and aft. It will be so even if the string be tied at some single point between A and A'. In general, however, a single cell can not be made to fly well, or even at all, but this is chiefly because the resultant couple Z_0 of the system of forces is generally of finite value, and there is little or nothing in the relation of the forces of the system to automatically neutralize this couple.

We have thus fully analyzed and discussed first the effects of changes in the wind and position of the kite upon the applied forces, and then shown in detail all the essential conditions and circumstances under which the equilibrium of the kite can be stable with respect to the resultant force R_0. To this end it is necessary only that the point F at which the string ends and the kite begins shall be in front of and not too near the supporting surfaces of the kite. If F is not fixed in a lateral sense, then we must establish conditions of automatic lateral stability, as described in detail above. By these methods the so-called *translational stability* of any kite may be fully and certainly established. It now remains to show how the resultant couple Z_0 may be neutralized when it attains finite values owing to changes of the wind, etc.

Rotational stability.—When kites are in equilibrium the action line of the string is then the *central axis* of the whole system of applied forces, and, ordinarily, stands roughly at right angles to the general plane of the kite surfaces. The axis of the couple Z_0 is not only necessarily parallel with this central axis, but in kites coincides with that axis itself because the kite is free to turn only thereon. Our purpose is now to discuss the means that may be employed to prevent or to properly regulate and control this turning, that is, to establish rotational stability.

If it were possible to make a kite such that the resultant couple Z_0 of all the forces would always be zero, no matter how the conditions of wind might change or how the kite might be turned about the string as an axis, then we might say that the rotational equilibrium of such a kite is perfectly neutral. On the other hand, if the couple Z_0 retains a finite value, no matter how much the kite may turn under the action of the couple, then we should say its rotational equilibrium is *unstable*. If, however, as the turning of the kite pro-

ceeds under the action of the couple Z_0, the latter, as a necessary result of the turning, is reduced in magnitude and made zero, then the rotational equilibrium is *stable*.

Function of the tail.—The whole useful function of the tail is to suppress and govern the action of the couple Z_0. In every other respect the tail is a useless and even objectionable appendage to the kite, but if it is properly adapted to its purpose the couple Z_0, when momentarily of finite value, is immediately reduced to zero, as a result of the action of the tail under the incipient rotation which ensues. This is readily understood from Fig. 20.

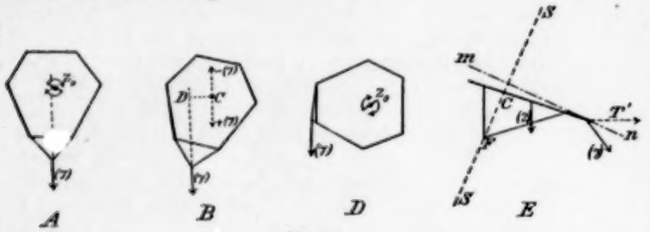

FIG. 20.

At *A* is shown a kite as it may appear when viewed exactly in line with the string, which intersects the kite at *C*. The force (7), due to the tail and the couple Z_0, are also shown. There being nothing initially to oppose the action of the couple, when its value becomes finite, the kite turns a little, but immediately that this occurs the action line of the tail force, (7), passes more and more to one side of the central axis of the system of forces, as shown at *B*, Fig. 20. The force is thus made to act at the end of a short lever, or moment arm *C D* and if the tail be adequate for its purpose, a slight turning of the kite causes such new relations between the forces, including that of the tail, that the resultant couple Z_0, which had momentarily attained a finite value, is reduced to zero. The action of the tail is in these cases equivalent to a couple as may be easily shown by introducing at *C* two forces, +(7) and −(7), equal and opposite to each other, and equal and parallel to the tail force (7). The latter force and the force —(7) at *C*, constitute a couple with the moment arm *C D*. The change in the position of the kite, resulting from the turning, has quite disturbed the equilibrium of the force R_0, but this is of no consequence, since the relations of this force to the string are those of stable equilibrium and a new position of rest will be quickly assumed. The important point is that in consequence of the action of the tail the couple Z_0 is prevented from maintaining a finite value for any considerable time. It must be noted, furthermore, that the couple-action of the tail does not have an independent existence. It is called into action by the general couple Z_0 of the whole system of forces. If the latter couple increases or diminishes, or changes sign, so does that due to the tail. The existence of the couple Z_0 results, in the main, from imperfections in the symmetry of the kite and from temporary inequalities in the wind forces at different points over the kite; also, from changes in wind direction. Z_0 is therefore, not permanently a very powerful couple, and, in consequence, a slight shift of the kite, of the nature shown at *B*, will, as a rule, effect its elimination, provided the force (7) is relatively considerable. The tail produces the maximum possible couple when in the position shown at *D*, but such an extreme turning of the kite is, of course, fatal to satisfactory flight. The usefulness of the tail depends upon its power to neutralize the couple Z_0 with only very small angular turnings of the kite. Gravity may also assist the tail in causing a couple to vanish. This is generally the case, because in most kites the *central axis* is nearer the forward edge than is the center of gravity. The action of gravity in this connection, and some further facts concerning the effect of the tail will be understood from an examination of *E*, Fig. 20, which shows the side view of the kite and string. It is a well-known result that gravity, acting at a point, *g*, on a body like *A B*, free to rotate about an axis such as *S S*, will make the body take a position about that axis such that *g*, when the kite is in its normal flying attitude, will be the lowest possible, or very nearly so. A couple such as Z_0, which tends to produce rotation about the axis, *S S*, must, in turning the kite, carry the point *g* to a higher position, and to this extent the turning will be opposed by gravity. The opposing power of gravity has, in general, however, only a relatively feeble moment of little importance. Our only object has been to call attention to its existence, as the principle may have great importance in the flight of birds and flying machines of considerable weight.

It should be noticed that, in general, the direction in which the force (7) due to the tail acts makes an angle below the horizontal, as shown at *E*, Fig. 20. In considering the effectiveness of the tail to nullify a couple, the force (7) must be resolved into two components, one parallel to the axis *S S*, and the other in a plane, *m n*, perpendicular to *S S*. The moment of this latter force with respect to the line *S S* is the only effective part of the force (7). The most effective tail is, therefore, one which would dispose itself in the plane *m n*, in which case the full power of the force (7) is effective in suppressing rotation. However necessary and useful the tail may be in contributing to the rotational stability of a kite, it is very plain that its force, (7), as may be seen in Fig. 4, tends to very strongly deflect the resultant *R* away from the normal *N*, and thus impair the effectiveness of the kite. If the pull of the tail could be upwardly inclined it would be much better, as there would then be exerted an advantageous lifting tendency. But this is, of course, impossible as a steady effect, unless, for example, the tail was rendered buoyant by inflation with gas.

Most efficient tails.—Now that we know the exact function of the tail we are prepared to state the conditions for maximum effectiveness. In the first place the necessity for a tail arises from the fact that, owing to some organic, permanent, and constant defect in the kite, the structure is unsymmetrical, and in consequence the couple Z_0 still exists when all the conditions of equilibrium are otherwise established. This couple may also assume relatively large temporary values when the wind suddenly shifts its direction in azimuth, as explained on page 150. The power of the couple will, on the average, be constant for a given wind force, although its momentary values will change more or less with inequalities of wind pressure on different parts of the structure. The power of the couple will also increase and decrease with the wind velocity. Now a tail which depends largely upon its weight for the force (7) will exert a nearly constant pull. In light winds it will pull the kite down and be unnecessary, while in heavy gusts it will be inadequate to overcome the increased moment of the couple Z_0.

The most efficient tail, therefore, is one without weight and whose pull depends upon the pressure of the wind. When properly adapted to a given kite for one wind velocity it should answer equally for other velocities, at least within comparatively wide ranges.

Tails made of very light pervious cloth in the form of frustrums of cones distended at the base by a large and at the summit by a relatively quite small ring of aluminum wire or rattan are seemingly the most efficient tails. Their weight may be reduced to the minimum and the pull they exert is nearly proportional to the wind force and nearly horizontal in direction.

Tails thus afford a means of controlling and regulating the magnitude of the resultant couple Z_0 of the system of applied forces. The rotational stability may, however, also be

established without the use of a tail, and this brings us to the consideration of a new class of kites.

Tailless kites.—From the mechanical point of view the presence or absence of a tail in the case of a kite is simply a question of the magnitude of the force (7). Thus far we have supposed the force (7) to have a finite magnitude; we will next consider those cases in which (7)=0. This supposition that (7)=0 is all that is necessary to adapt the whole foregoing theory to tailless kites.

Referring to Fig. 10, showing the relation of the forces on a kite, it will be recalled that the central axis, S_0 S_0, of the whole system of forces is parallel to the force C' R, and separated from it by a distance, x, depending upon the nature of the couple Z. If now the force (7) is zero, then the line Q R of the polygon of forces, which line is equal and parallel to (7), will vanish and the resultant of all the forces that remain will be represented by a line C' Q instead of C' R. The couple associated with the new resultant, C' Q, will, of course, have a value depending upon the forces of wind and gravity on the kite alone, exclusive of the tail. Likewise, the new central axis will be parallel to C' Q and a change will occur in the distance, x, corresponding to the difference between the new and the original couple Z. Finally, the resultant couple Z_0 acquires a new value and may even change its sign.

We thus find that if we omit the tail from a kite, other things remaining the same, the total resultant of the applied forces may be greater in magnitude, will assume a more nearly vertical direction, and will shift its position. Supposing the kite is able to fly either with or without a tail, it follows from the above that, if the incidence of the kite surfaces to the wind and other things be kept the same, the kite will often pull harder and always fly higher without than with the tail. Removing a tail from a kite or adding it thereto will, in general, cause the kite to assume a different angle of incidence when equilibrium is attained. This may be offset by a corresponding change in the bridle or it must at least be taken into consideration if we wish to compare the behavior of the kite in the two cases.

Such are the general relations between the forces acting upon a kite with and one without a tail. Our particular purpose at present, however, is to show what contributes to the rotational stability of tailless kites.

The rotational equilibrium of all flat surface kites, of which the form shown in Fig. 6 may be regarded as representative, is always likely to be quite unstable without a tail. The couple Z_0 when finite is free to turn the kite about the string as an axis and generally to an indefinite extent. It is conceivable that the symmetry of such a kite may be so perfect that the couple Z_0 can not have permanent finite values under steady winds, or that the values may be so small that the feeble opposing couple resulting from the action of gravity may suffice to prevent rotation. These are not probable cases, and while a very slight degree of stability may thus be gained, yet, in fact, as every one knows, a kite of this type with insufficient tail is likely to dart about in the most unsteady manner and, if without any tail whatever, will often spin about the string as an axis at a very high velocity.

It is possible to contribute a slight degree of rotational stability to a flat surface tailless kite by adding weights to the aftermost end of the kite, and this method has sometimes been adopted. It increases the gravity of the kite, and shifts the center of gravity to a point farther aft, and therefore, as a rule, farther from the axis of the couple Z_0, which is the *central axis* of the system of forces. Both these effects increase the relatively feeble opposition that the action of gravity on the kite offers to its being rotated out of a position in which the center of gravity is the lowest possible.

Another method is more generally employed, which also gives only a slight degree of stability. It consists in arranging loose flaps of cloth or covering material near the after end of the kite. The kite itself is sometimes made flexible in the aftermost portion by shaving the sticks down thin and attaching the bridle strings at some distance from the ends. In either case, these flexible portions flap and flutter in the wind to a greater or less extent, and thereby exert a small force approximately in the direction in which the air is flowing over the surfaces. Some mention has already been made of this point under the discussion of waviness and fluttering on page 141. The force, in fact, is not unlike the regular tail force (7) and acts exactly the same, but in a less powerful manner to suppress the couple Z_0, that is, to keep the kite headed to the wind.

Loose fluttering appendages of this character are conspicuous in many different forms of chinese, bird, and butterfly kites, and in still other forms of oriental kites. In many cases the flaps are so disposed that under the pressure of the wind the surface is formed into dihedral angles near the aftermost portion of the kite, and, even if the loose material does not flutter and vibrate, the action of the side thrust of the wind on the slightly inclined surface at the back end of the kite tends to prevent rotation of the kite about the string.

Such means as we have just discussed will suffice to control flat surface kites in moderate winds, but will generally prove inadequate in strong gusty winds, and in such cases tails must often be called into requisition.

Dihedral angle.—We have already shown that a degree of *lateral stability* is imparted to a kite by placing the lateral halves of the surfaces at a dihedral angle with each other. This arrangement also produces a degree of rotational stability. All those kites of which the malay and Eddy kites are typical, including many oriental tailless kites whose framework is pliable and yields under the strain of the wind so that the lateral surfaces form a dihedral angle, acquire a degree of *rotational stability* as a result of this disposition. It is well known that these kites fly best when the covering material is pliable rather than stiff. It should be tense and fit closely over the forward portion of the kite and be loose and form concavities in the rear part. Under the pressure of the wind the loose and pliable covering forms a sort of keel, especially pronounced along the after portion of the midrib or upright stick of the kite. If the kite turns a little under the action of the couple Z_0 when its value becomes finite, the keel must swing sidewise against the wind and a very little turning under these circumstances reduces the couple Z_0 to zero. It is especially because the keel is deeper and more pronounced when the cloth is pliable and loose, that all these kites then fly better.

In considering questions of *rotational stability* in kites of the malay or Eddy type it should be noticed that the action line of the string, that is, the central axis of the system of forces and also the axis of the couple Z_0, cuts the surfaces at a point only a short distance to the rear of the cross stick of the kite. This position is relatively close to the front edge of the kite, whereas, the keel-like disposition mentioned above is most conspicuous well toward the after end of the kite, a relation which is most effectual in producing rotational stability.

Boynton fin kites.—The use of genuine keels or fins, especially if they are cut away forward and are present only in the after parts of the kite, are still more effectual in suppressing the couple of the system of forces, and they may easily be arranged so that the kite to which they are attached can fly without a tail. The same remarks are equally true of the bipolar kite.

Bipolar kites.—In these the central spine is extended aft beyond the body plane and carries both a vertical and horizontal plane. The vertical plane, on account of its consider-

able distance aft from the central axis of the forces, affords a very powerful control upon the rotation of the kite under the action of the couple Z_0.

Cellular kites.—We have already remarked that the great stability of the Hargrave kite results from the relatively great extent of neutral surfaces composing the lateral sides of the cells. The presence of these not only establishes a great degree of lateral stability, as already explained, but the neutral webs in the aftermost cell also act in the most advantageous manner to produce *rotational stability*, as is readily understood from what has been said above concerning the action of keels, fins, etc. Longitudinal stability results both from the superposition and the separation of the supporting surfaces and also from the use of a bridle, causing the point F, at which the main line is attached, to fall in front of the kite.

Steadiness.—The quality of steadiness in flight depends, as we have seen, upon the circumstance that the couple Z_0 and the resultant R_0 are *simultaneously* neutralized. Very many forms of kites are deficient in *rotational stability*, and slight inequalities of wind force very easily turn them considerably about the string as an axis. This alters the attitude of the kite to the wind, and thus causes the kite to shift its position in order to reestablish *translational equilibrium*. The greatest steadiness results when the *rotational equilibrium* is the most stable. This is why kites with an abundance of tail power fly so much more steadily than those with deficient tails.

The foregoing exposition of the action of the forces of wind, gravity, and the string upon kites suffices, we believe, to fully explain their behavior under all circumstances. The analysis of the conditions upon which stability and steadiness depend embraces every type of kite, not only the numerous odd forms constructed by the Chinese and Japanese, which, in many cases, are only adapted to sport and often fly at relatively low angles of elevation, but includes also the malay, the fin, the bipolar, and all forms of cellular kites. We have aimed in our presentation of the mechanics of kites to state the generic relation and interaction of the applied forces. The principles thus laid down have a very wide and comprehensive application.

Numerical data.—In regard to the questions raised in Mr. Chanute's letter at the head of this memoir as to the positions of the center of gravity, center of pressure, and best point of attachment for the string, we may repeat here a statement already made that, in general, it is better to have the center of gravity fall farther aft than the so-called center of pressure, as gravity then assists in producing rotational stability. This position generally comes about without design on the part of the maker, but it is conceivable that a kite with a tail might fly with the center of gravity even forward of the center of pressure.

The indefiniteness of this conception, "center of pressure," has already been fully discussed. A *central axis* is the idea to be kept in mind in this connection, and if we include all the forces of wind, gravity, and tail, the central axis always coincides with the action line of the string when the kite is in equilibrium. As we have shown, the position and direction of this action line changes with every change in the force and direction of the wind and variation in the attitude of the kite. The central axis may be completely located in a given case by simultaneous measurements of the incidence of the kite, its angular elevation, and the inclination of the kite line at the reel. The axis always passes through the point F, at which the string is fastened to the kite. Methods of making the simultaneous measurements for this purpose have been fully described by the writer in "Kite Experiments at the Weather Bureau," pages 82 to 87 (reprinted from the MONTHLY WEATHER REVIEW, 1896, Vol. XXIV, p. 240), and it seems unnecessary to repeat the descriptions here.

The best point of attachment for the string depends partly upon the use to which the kite is to be put. Changes in the point of attachment cause changes in the angle of incidence which the surfaces assume to the wind. For reaching great altitudes certain angles of incidence are better than others. This subject has also been fully discussed in the pamphlet referred to above, and the results will be found on pages 98 to 103 (see MONTHLY WEATHER REVIEW, Vol. XXIV, p. 250). To repeat these demonstrations here will greatly extend the limits of this paper, and appears unnecessary.

X.—NUMERICAL DATA.

The gathering of numerical data derived from actual observations made by sound and accurate scientific methods is a matter of considerable labor and difficulty. Work of this character done by the writer for the Weather Bureau, in order to determine the efficiency and availability of kites for reaching high altitudes, has thus far extended only to various types of cellular kites, which, as a class, all things considered, are probably the most stable and available of all. Very complete numerical data respecting these kites have been published in the "Kite Experiments," pages 56 and 87 (see MONTHLY WEATHER REVIEW, Vol. XXIV, p. 244). The following additional example is cited from recent work:

Hargrave rectangular cell.—Each cell 78 inches from side to side; 32 inches from top to bottom surfaces. The cambric cloth bands, including the flat, spruce sticks (¼ by ⅛ inch) in the form of rectangular frames, with which the cloth is edged all around, are 25.2 inches (2.1 feet) wide. The front cell has a third sustaining surface midway between the upper and lower surfaces of the cell. The two cells are connected by a longitudinal truss. The upper and lower spines are spruce sticks (¼ by ⅛ inch) spread out by four columns and properly braced by wire ties. The extreme length over the cells is 79 inches. This kite contains 68.2 square feet of sustaining surface, and weighs 7.32 pounds, viz, 0.107 pound per square foot. The bridle is made of a single bight of string attached to the front and rear edges of the lower side of the front cell. The center of gravity is 1.6 inch forward of the center of figure. By actual observations in a wind of from 12 to 15 miles per hour the *central axis* of the system of forces was found to make an angle of 83° with the general plane of the sustaining surfaces, and intersected the lower surface of the front cell at a point 8 inches aft of the forward lower edge. The angle of incidence of the kite averaged 24.8°, and the pull, which varied greatly, averaged about 25 pounds. The efficiency of the kite was 92 per cent.

The simultaneous observation of all those elements of the flight of a kite that are necessary in order to accurately determine "the pull thereon, with various positions and with various strengths of wind," in its broadest sense, is equivalent to the determination of the law of relation between wind velocity and the pressure upon the surface of the kite at various angles of incidence. This is a matter which, if the results are to possess real scientific value, presents very serious experimental difficulties which are greatly aggravated by the extreme variability of the wind. Simple methods that may be imagined to give sufficiently approximate results are found upon trial and critical inspection to be exceedingly unreliable, and to yield widely misleading numerical values. The pull, if measured at the reel, must be reduced to its corresponding value at the kite, and the simultaneous velocity of the wind must also be definitely measured *at the kite*. Due allowance must be made for the weight of the kite, and the fact that in cellular kites the pressure of the wind per unit area upon the surface of the forward cell is much more intense than upon that of the rear cell must be properly recognized if the final results are to be susceptible of useful application in other cases. Investigations have shown the writer at least the real experimental difficulties of securing accurate data of this character, and he is not prepared at present to cite results whose accuracy can be fully defended.

XI.—THE MECHANICS OF THE KITE STRING.

Thus far in the study of the behavior of kites, and in the analysis of the forces acting thereon, we have considered only

the kite with a short piece of string or restraining line immediately next to it. We now wish to study the forces acting upon the line, with a view to clearly setting forth in what manner and to what extent these forces limit the elevation attainable with a given kite and the position it assumes.

If we could employ a string or wire having no weight, and so fine that the pressure of the wind upon it would be wholly inappreciable, then, as more and more of this wire is paid out to it, the kite would pass outward and upward along the same straight line, such as $R\,K$, Fig. 21, retaining always the same

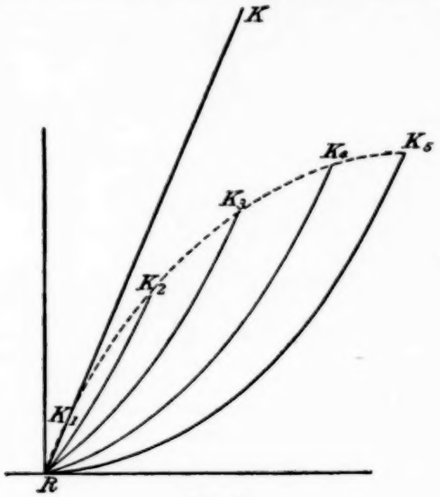

FIG. 21.

angular elevation as seen from the reel. Provided the wind continued unchanged in force, there would be no limit to the height to which a kite could be flown under such circumstances. Unfortunately, however, we can not fly kites with wire having no weight, and against which the wind will not press, and, in consequence, our actual kite behaves in a very different manner from that described above. Supposing, as before, that the wind force is the same at all points, high or low, the results actually obtained with the kite above employed will be something like the following: When but a short length of wire is paid out to the kite, it will take its position upon the same line, $R\,K$, as before; that is, for example, at K_1. When more wire is unreeled, the kite does not continue upward on this line, but, instead, drifts gradually away to leeward and assumes, successively, such positions as at K_2, K_3, K_4, etc., which positions lie on a curve identical with that of the line, but having the ends and sags reversed. An important feature, common to all of the positions the kite may assume, is that *the portion of the wire next the kite remains always at exactly the same inclination*. The inclination is not only the same for all positions, but is the same as it originally was at $R\,K_1$. Changes of the wind force and other influences may cause this inclination of the wire to change, but the mere reeling out or in of the wire itself has no effect on the inclination. With a certain amount of wire out, the portion next the reel becomes horizontal, and the limit of altitude is then reached. The kite can lift no more line. All these effects have been brought about under the limitations imposed by the action of gravity and the wind upon the wire. We have mentioned the wind equally with gravity as affecting the wire. It is probable that with moderate wind forces the pressure upon wire, owing to its fineness in proportion to its weight and strength, is a smaller and less important force than gravity. With a given weight of line the maximum of strength and the minimum of wind effect are obtained by the use of tempered steel music wire.

By the aid of well-known mathematical formulæ we can determine in the most complete and exact manner all the effects due to the action of gravity on the wire. On the other hand, the effects of the combined action of wind and gravity are of a very complex character, and but little known and understood and can be mathematically represented only in a most general and imperfect manner. The effect of the wind pressure on the wire will be disregarded in the present treatment, and we will proceed to develop the properties of the curve assumed by the kite wire, as if it were dependent upon gravity alone.

XII.—PROPERTIES OF THE CATENARY.

The catenary, which is approximately the curve assumed by a kite line of steel wire, possesses many very remarkable and interesting properties that have a more or less important bearing upon the art of flying kites. A comparatively full discussion of these will be found in the published account of Weather Bureau work. We will reproduce here only a few of the most important equations.

The fundamental equations of the catenary may be written in a variety of forms, depending upon the variables employed. Each equation expresses some interesting property of the curve. Some of the forms most convenient for use are the following:

$$y = \sqrt{s^2 + c^2} - c \tag{1}$$

$$x = c \operatorname{nap} \log \frac{s + \sqrt{s^2 + c^2}}{c} \tag{2}$$

$$\tan \theta = \frac{s}{c} = \frac{d\,y}{d\,x} \tag{3}$$

$$t = w\,(c + y) \tag{4}$$

In these equations x is measured horizontally and y vertically, and the origin of coordinates is taken at the point where the curve is horizontal; s is the length of the curve measured from the origin; c is a constant; θ is the angle of inclination of the curve to the horizon at the upper end of a portion of length s; t is the tension at this upper end, and w is the weight per unit length of the material of which the catenary is formed.

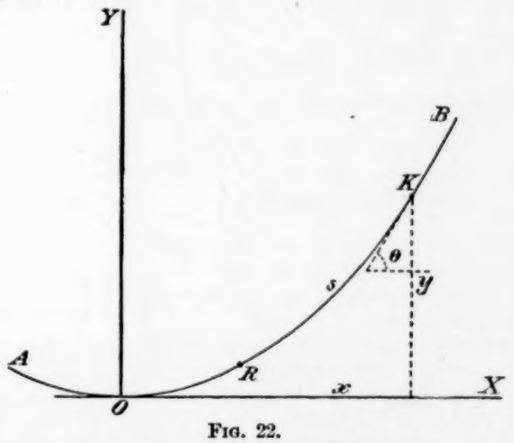

FIG. 22.

In Fig. 22 let $A\,O\,B$ represent a catenary. The curve has similar branches on either side of $O\,Y$, but we are generally concerned with only a portion of the curve on one side. If the wire at the reel is just horizontal, then the position of the reel will be represented by the point O in the diagram. If the wire at the reel is inclined upward, more or less, then the position of the reel will be represented on the diagram by some such point as R, at which point the curve is inclined at the same angle as the wire at the reel.

Tension.—The quantity c, in the equation above, is given by the expression $c = \frac{t_0}{w}$. That is, c is the length of a piece of wire whose weight equals t_0, the tension in the curve at the lowest point, where x, y, s, and θ are all zero.

If t, θ and t', θ' are, respectively, the tensions and inclinations of the curve at any two points, then, from equations (1), (3), and (4), there results,

$$\frac{t}{t'} = \frac{\cos\theta'}{\cos\theta} \tag{5}$$

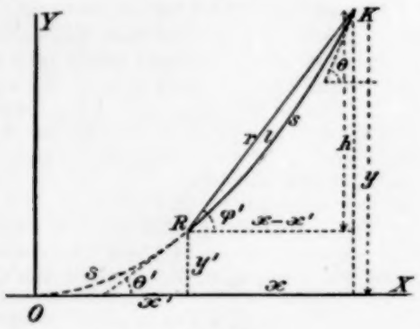

FIG. 23.

General equations for partial ascensions.—Fig. 23 represents a partial ascension in which the reel is at R and the kite at K, with the origin of coordinates at O. Letters designating the coordinates of the catenary at the point representing the reel are distinguished by a superscript ($'$). The linear elevation of the kite is $h = y - y'$ and the length of wire out is $l = s - s'$.

If t' is the tension of the wire at the reel, then the linear height of the point R above the origin of coordinates is given by the equation

$$y' = \frac{t'}{w}(1 - \cos\theta')$$

The length of the catenary from R to the origin is

$$s' = \frac{t'}{w}\sin\theta'$$

Eliminating c from equation (1) by its value in terms of t' and θ' and replacing s by its value $s = l + \frac{t'}{w}\sin\theta'$ we obtain,

$$y = \sqrt{l^2 + \frac{2lt'}{w}\sin\theta' + \left(\frac{t'}{w}\right)^2} - \frac{t'}{w}\cos\theta'$$

Whence,

$$h = y - y' = \sqrt{l^2 + \frac{2lt'}{w}\sin\theta' + \left(\frac{t'}{w}\right)^2} - \frac{t'}{w} \tag{6}$$

That is, when the length of wire out is known, together with the tension and inclination at the reel, we may deduce the height of the kite, even when it is concealed from view, as by clouds, darkness, its remote distance, etc. This results from a general property of the catenary and the equation is equally applicable to the case of either partial or complete ascensions. Owing to great momentary variations that take place in the tension of the wire the calculations of elevations depending upon the tension at the reel will not, as a rule, be as accurate as those deduced by other methods, but equation (6) will undoubtedly prove useful in cases where other methods of ascertaining elevation are not available.

The elevation of an invisible kite deduced by equation (6) will be more accurate as the sag in the wire is greater.

If θ and t are the inclination and tension of the wire at the kite, we may write,

$$y = \frac{t}{w}(1 - \cos\theta), \text{ and } y' = \frac{t'}{w}(1 - \cos\theta')$$

whence, by equation (5), we get,

$$h = y - y' = \frac{t}{w}\left(1 - \frac{\cos\theta}{\cos\theta'}\right) = r\sin\Phi' \tag{7}$$

Slack in the wire in partial ascensions.—Let r be the length of the chord of the catenary from the reel to the kite, and Φ' the angular elevation of the kite from the reel, then,

$$r = \frac{h}{\sin\Phi'}$$

$$\text{slack} = l - r \text{ and percentage of slack} = 1 - \frac{r}{l}$$

The ratio of any chord of a catenary to the corresponding arc is given by the equation

$$\frac{r}{l} = \frac{\cos\theta' - \cos\theta}{\sin\Phi'\sin(\theta - \theta')} \tag{8}$$

which may be obtained from equation (7) by eliminating $\frac{t}{w}$ in terms of l.

The relation between Φ', θ, and θ' is obtained from equation (2) together with the value of h in (7), thus,

$$\tan\Phi' = \frac{h}{x - x'} = \frac{\sec\theta - \sec\theta'}{\text{nap log}\left[\frac{\sec\theta + \tan\theta}{\sec\theta' + \tan\theta'}\right]} \tag{9}$$

In this equation Φ' is the angular elevation of the kite, as seen from the reel.

The following table contains a series of values of Φ' deduced from equation (9) corresponding to such assumed values of θ and θ' as may occur in practice. With each value of Φ' is also tabulated the corresponding percentage of slack computed by means of equation (7). The results are rigorous representations of the properties of the catenary, and even though the wind effect has been omitted, the relations of the quantities concerned are such that the wind effect on the wire can not modify *the percentage of slack*, corresponding to given values of Φ' and θ', except by a quantity of secondary magnitude.

Angular elevation and percentage of slack.

Inclination of wire at kite.		θ' = Inclination of wire at reel.						
		0°	10°	20°	30°	40°	50°	60°
$\theta = 50°$	Slack, per cent.	3.22	2.03	1.11	0.51	0.13	.....	.....
	Φ'	28.8°	32.9°	36.9°	41.0°	45.3°	.....	.....
$\theta = 55°$	Slack, per cent.	3.87	2.55	1.53	0.78	0.29	0.03	.....
	Φ'	32.8°	36.6°	40.4°	44.2°	48.2°	52.5°	.....
$\theta = 60°$	Slack, per cent.	4.53	3.10	1.97	1.11	0.50	0.13	.....
	Φ'	37.2°	40.8°	44.3°	47.8°	51.4°	55.4°	.....
$\theta = 65°$	Slack, per cent.	5.17	3.65	2.43	1.48	0.76	0.28	0.03
	Φ'	42.2°	45.4°	48.5°	51.7°	55.0°	58.5°	62.6°

Elevation attainable.—It is desirable to know how much pull and what length of line is necessary in a given case to reach a certain elevation, that is, to sustain the wire from the kite down to the reel. The pull may be deduced by solving equation (7) for t. The length of line required may be found by the equation,

$$l = \frac{t}{w}(\sin\theta - \cos\theta\tan\theta')$$

The steel wire used as kite line by the writer is 0.0285 of an inch in diameter and weighs 2.155 pounds per 1,000 feet. The table below gives the pull and the amount of line required to reach certain elevations, depending upon the inclination θ, at which the kite pulls the wire and also the angle θ', to which the wire is permitted to sag at the reel. The wind effect on the wire is neglected, and necessarily so from our present ignorance of the numerical magnitude of these effects. The results are, therefore, not exactly representative of actual kite ascensions. The discrepancies will be small in moderate winds, that is, under 20 miles per hour, but become more important at this and higher velocities.

Essential elements in kite ascension.

$w = 2.155$ lbs. per 1,000 ft.

$$t = \frac{wh}{1 - \frac{\cos\theta}{\cos\theta'}} \qquad l = \frac{t}{w}(\sin\theta - \cos\theta\tan\theta')$$

h.	θ'	θ=50°		θ=60°		θ=70°	
		l	t	l	t	l	t
Feet.		*Feet.*	*Pounds.*	*Feet.*	*Pounds.*	*Feet.*	*Pounds.*
2,000	θ'=10°	3,756	12.4	3,162	8.8	2,693	6.6
	θ'=20°	3,367	13.6	2,926	9.2	2,565	6.8
4,000	θ'=10°	7,511	24.8	6,324	17.5	5,386	13.2
	θ'=20°	6,739	27.3	5,853	18.4	5,130	13.6
6,000	θ'=10°	11,267	37.2	9,485	26.3	8,080	19.8
	θ'=20°	10,102	40.9	8,779	27.6	7,694	20.3
8,000	θ'=10°	15,022	49.6	12,647	35.0	10,773	26.4
	θ'=20°	13,469	54.6	11,706	36.8	10,259	27.1
10,000	θ'=10°	18,778	62.0	15,809	43.8	13,466	33.0
	θ'=20°	16,836	68.2	14,632	46.1	12,824	33.9

It is asked "What is the difference in effect between the kite string and the attraction of gravity on the mass of a soaring bird?"

The effects are very different in many respects. In the first place the string constrains its kite to move in a certain definite surface of constraint which, in general, is sensibly a spherical surface. Gravity does not exercise any similar constraint upon the bird. Secondly, the tension or pull of the string may act in many different directions, and with a magnitude which depends almost entirely upon the pressure of the wind upon the kite; that is, if the wind suddenly stops blowing, the string will quite as suddenly slacken up entirely and the feeble pull it exerts due to its direct weight will be in a new direction, and will often be but a small fraction of its original pull. The tension in the string is not a *primary* but a dependent force. The force of gravity on the bird is, however, a primary force, is always constant in amount, and its direction of action is always vertical. We do not consider that there is any real mechanical analogy between the effects of the force of gravity on a bird and the pull of the string of a kite. Without the restraint of the string the kite and the bird are similar in that both are subject to the attraction of gravity, and both expose certain surfaces to the action of the wind. The kite completely lacks the intelligence or instinct of the bird, but stable forms of tailless kites cast adrift in the wind are carried long distances before reaching the ground. Two large Hargrave kites broke away from the writer in a violent rainstorm when at a height of about 7,000 feet. The total supporting surface was about 80 square feet, and the weight 8 pounds plus the effects of rain and several pounds of wire. These kites drifted 15 miles before reaching the ground and descended entirely uninjured.

NOTES BY THE EDITOR.

SEASONAL FORECASTS FOR OREGON.

On the morning weather map of April 12, published at Portland, Oreg., Mr. B. S. Pague, Local Forecast Official, says:

The first summer type of weather conditions appeared Saturday night and Sunday and continues this morning. The appearance of this type marks the commencement of the summer or dry season and the passage of the winter or wet season. From now on until the first appearance of the winter conditions next autumn, fair weather is more probable than rainy weather. Summer conditions do not mean absolute dryness, but rather fewer rainy periods, more sunshine, and more warmth.

In 1895, the first appearance of summer conditions appeared on April 20; rain fell in that year from April 30 to May 9 in showers, and again from May 20 to May 30, the total being 3.42 inches. June had rain on two days. May was cool, and June had normal temperatures.

In 1896, summer conditions did not appear until June 13, and then, except a few sprinkles, no rain fell until August 1, when showers occurred for five days.

Winter conditions appeared in 1895 on November 12, and in 1896 on October 20. Frosts west of the Cascades are not, as a rule, injurious after the appearance of summer weather conditions.

Summer conditions are distinguished from winter by the movement of the areas of high and low pressures. In the summer the highs move from off the central California coast northward along the coast to about 50° north latitude, thence eastward. Cool weather appears when the high is between Cape Mendocino and the Columbia River, and it is warmer when the high is moving over the Coast and Cascade ranges. The warmest occurs when the high is to the northeast of Spokane. Under the summer conditions, the low areas retreat to the north and pass eastward about the latitude of Sitka; for this reason, summer rains prevail in Alaska.

CLOUD HEIGHTS—A PROBLEM FOR STUDENTS.

On a preceding page we have published Mr. H. H. Clayton's modification of Feussner's method of computing the height of a cloud by observations of the location of its shadow. This modification consists essentially in applying the double or check computation first extensively introduced by Ekholm and Hagstrom into the so-called parallactic method. The formulæ for the computation are essentially the same as were arranged a year ago by Professor Bigelow for use at the Weather Bureau, in reducing simultaneous cloud observations made at the two ends of a fixed base line.

As the trigonometrical relations are very simple it is to be hoped that many of our intelligent observers will interest themselves in determining frequently the actual heights and motions of the clouds. There are many methods of doing this and these, together with new ones that yet remain to be invented, constitute problems that may well interest every youth when studying trigonometry and its practical applications. Such problems should be explained in our high schools and colleges generally, as an interesting practical example of the use of trigonometry. It is customary for our universities to require special original work from those who are candidates for the higher degrees, such as B. S., M. S., D. S., C. E., A. M., Ph. D., etc. To those candidates who are interested in the atmosphere and terrestrial physics we earnestly recommend the study of the clouds, their altitudes, motions, and laws of formation as a thoroughly appropriate problem and one of the greatest importance to meteorology. The following special deduction of Ekholm's formulæ, as needed in Feussner's method, will interest such students. Nearly all the known methods are enumerated in the Editor's Treatise on Meteorological Apparatus and Methods, Washington, 1887, except that based on the use of the nephoscope at sea, which has been elaborated since then by Finemann and the Editor. Doubtless other methods remain to be in-

vented and we shall be glad to publish them if communicated by our observers.

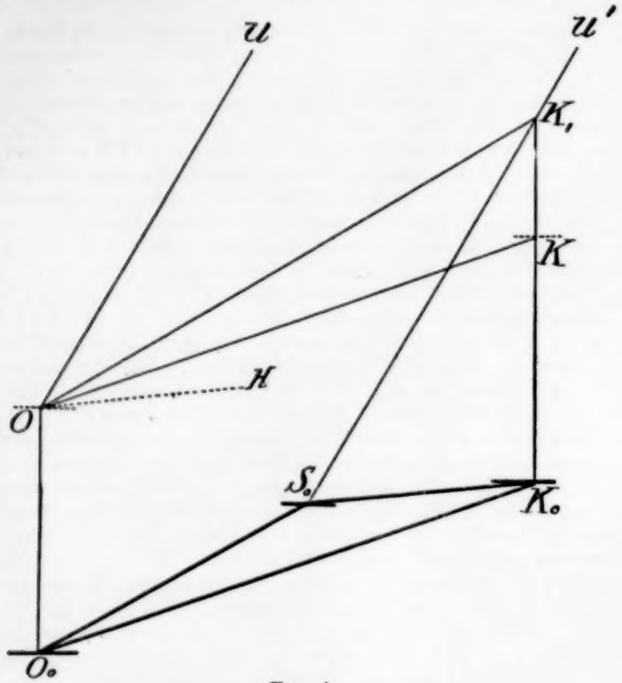

FIG. A.

In Fig. A let O be the observer and O_0 a point below him on the level of the observed shadow of the cloud. Let K_1 be the cloud and S_0 its shadow, the sun being at U or U'. Let K_0 be a point vertically below the cloud and on the same level as S_0. The points O_0, S_0, and K_0 are all on the same lower level and the azimuths, as measured at O, being measured in a horizontal plane, will be the same as the azimuths of these three horizontal lines forming the triangle $S_0O_0K_0$. The azimuths may be measured either from the south point westward or in any other manner most convenient to the observer it matters not which, as only the differences come into consideration at present. The observations are most naturally made in the following order: First, identify the cloud with its shadow and locate the shadow by a mark on the detailed topographical map, as at S_0 in Fig. A and also note the time. The observer at O must then immediately, with his nephoscope, or an equivalent alt-azimuth instrument, observe the apparent altitude of the cloud (or the angle K_1OK or h_1); the azimuth of the cloud (or the azimuth of the line OK or O_0K_0, which is a_1); the apparent altitude of the sun (the angle UOH or $U'S_0K_0$, which is h_2); the apparent azimuth of the sun (which is the azimuth of the line OH, or the parallel line S_0K_0 or a_2). He then determines at his leisure by measurement on the map the azimuth of the cloud shadow (which is the azimuth of the line O_0S_0 or a_3); the distance of the shadow (which is O_0S_0 or b); finally, the difference in level between O and S_0, as shown by the contour lines (which is c or the vertical lines OO_0 or KK_0).

We now have the following simple trigonometrical relations:

$$K_0O_0S_0 = A_2 = a_3 - a_1$$
$$S_0K_0O_0 = A_3 = a_1 - a_2$$
$$O_0S_0K_0 = A_1 = a_2 - a_3 + 180^\circ$$

Thus all the angles and the side O_0S_0 are known in the triangle $O_0S_0K_0$. The subsequent work consists in computing the other sides O_0K_0 and S_0K_0, which are respectively the bases of two vertical right-angled triangles, in which we know the vertical angles KOK_1 or h_1, and $K_0S_0K_1$ or h_2. With these we now compute both KK_1 or z_1, which is the height of the cloud above the horizontal plane through O and also K_0K_1, which is the height of the cloud above the horizontal plane through O_0. From the latter we subtract the known quantity K_0K or O_0O which leaves KK_1; the latter is, therefore, a second computed value, which should agree with the one just previously computed from the triangle KOK_1. The entire system of formulæ for the solution is as follows:

$$OK = O_0K_0 = \sin A_1 \frac{b}{\sin A_3}; \quad KK_1 = z_1 = O_0K_0 \tan h_1$$

$$S_0K_0 = \sin A_2 \frac{b}{\sin A_3}; \quad K_0K_1 = z_2 = S_0K_0 \tan h_2$$

$$z_1 = b \operatorname{cosec} A_3 \tan h_1 \sin A_1$$
$$z_2 - c = b \operatorname{cosec} A_3 \tan h_2 \sin A_2$$
$$z_m = \tfrac{1}{2}(z_1 + z_2 - c)$$
$$\Delta z = z_1 - (z_2 - c)$$

If the shadow be watched for a few seconds and located again on the chart or at S_0' then these two locations give directly the direction of motion and the velocity of the shadow, which are the same as for the cloud.

The two values z_1 and $z_2 - c$ evidently ought to agree closely with each other, but for a number of reasons discrepancies are generally present. These arise mostly from the fact that the centre of the cloud as observed from O is not necessarily identical with that portion of the cloud that corresponds to the centre of the shadow. This fact becomes apparent as soon as we consider the very irregular shapes of the clouds. The two centers could only coincide when the cloud is a symmetrical figure. The same would be true if instead of the shadow at S_0 an observer had been stationed there with his theodolite and simultaneous observations had been made without reference to the sun. In general, the lines of sight from O and S_0 will pass through the cloud, but they may pass by each other without intersecting, or they may intersect at some point much nearer or farther than the cloud. In addition to this principal source of discrepancy there are unavoidable errors of pointing and measuring to be considered which may aggravate the error of the assumption just explained. The question therefore recurs which of the computed values of z is to be adopted or what combination of them will give the most probable result. Different students have adopted different rules in this matter, *e. g.*, Ekholm and Hagstrom adopt the location of the center of the shortest line that can be drawn between the two sight lines OK_1 and S_0K_0; that is to say, if these lines do not intersect as they ought to do Ekholm adopts the point of nearest approach to intersection. As this involves much extra computation, Professor Bigelow adopts the simple average of the two computed altitudes. In very accurate measurements, where all sources of error are carefully attended to and where the observed point is very definite as in geodesy, the method of Ekholm and Hagstrom is preferable, but in cloud work, where the observers are almost inevitably sighting upon different points of the same cloud, their method may have no advantage over that of Professor Bigelow. The proper combination of two or more observations so as to determine the most probable height of some definite point within a cloud, and thence the location of the top and bottom points of the cloud, is a question still to be settled.

THE FRANKLIN KITE CLUB.

In the MONTHLY WEATHER REVIEW for 1896, pp. 114, 206, 334, and 416, we have quoted a reference to the Franklin Kite Club at Philadelphia, and its report on the discovery of

ascending columns of air, as printed by Espy at page 167 of his Philosophy of Storms. The Editor has recently discovered that this reference to the Kite Club, as well as the whole of pages 161–168 of the Philosophy, is quoted by Espy from pp. 34–40 of an Essay on Meteorological Observations, by J. N. Nicollet, which essay is dated May 6, 1839. Nicollet, in these pages, fully indorses Espy's views, which, as he says, are recommended by the American Philosophical Society of Philadelphia, and it is quite possible that he has simply reproduced some one of Espy's numerous writings, however, Nicollet's pamphlet enables us to conclude with considerable confidence that the report of the Franklin Kite Club was published in or before 1838. No copy of this report has, as yet, been discovered, and it is considered exceedingly desirable that copies should, if possible, be deposited in some of the larger public libraries, where they will be preserved on account of their historical interest.

If any of the older meteorological observers possess copies of the circulars and instructions issued by Espy or the Joint Committee, during the years 1834–40, or if they possess newspapers containing reports of Espy's lectures, or any other matters of interest in the history of meteorology, the Editor will be glad to hear from them. Old manuscripts, papers, and pamphlets that have descended from one generation to another until they have become an incubus should never be destroyed or sold for waste paper until some competent librarian or historian has had an opportunity to examine them thoroughly and decide whether they are not worth purchasing and preserving permanently.

THE KITE AS USED BY ESPY.

Even before the work done by the Franklin Kite Club we note that Espy used the kite to determine the altitude of clouds as a check upon his computations, based on the dew-point of the air near the surface of the ground. His active mind had perceived that the altitude of the base of a cloud depends upon the rate of cooling of ascending moist air. The following paragraph must have been written between 1833 and 1837, and is quoted from page 75 of Espy's Philosophy of Storms:

> I would recommend that gentlemen residing in mountainous districts, where the clouds sometimes form on the sides of the mountains, should ascertain the perpendicular heights of these clouds at their bases and see whether they are 100 yards high for every degree of Fahrenheit by which the temperature of the air is above the dew-point at the moment of their formation. * * * Since writing the above a kite was sent up into the base of a cloud and its height ascertained by the sextant and compared with the height calculated from the dew-point, allowing 100 yards for every degree by which the dew-point was below the temperature of the air, and the agreement of the two methods was within the limits of the errors of observation. In this case the base of the cloud was over 1,200 yards high. Moreover, the motions of the kite whenever a forming cloud came nearly over it proved that there was an upmoving column of air under it. I speak of cumulus clouds in the form of sugar loaves with flat bases.

In his third meteorological report, paragraph 81, written about November, 1850, and reprinted also as paragraph 81 in his fourth report, Espy says:

> When the kite experiments mentioned before were performed and the kite was allowed to stay up in the air many hundred yards high in the night, by touching with the hand the reel on which the wire was wound which was attached to the kite, the *fingers became luminous*, quite brilliant, though no sensation of a shock was produced; but by touching the wire itself a very pungent shock was experienced; and one day in particular when the kite entered the base of a forming cloud the discharge of electricity down the wire, snapping to an iron conductor stuck in the ground, terminating at its upper end within an inch or two of the wire, became fearful.
>
> In the case of the meteoric rivers (*i. e.*, cloudbursts) the friction of the water through the air in falling might be supposed to generate electricity which rendered them luminous; but the friction of the wind on a kite eight feet square could evidently not be sufficient to account for the great quantity of electricity constantly passing down the wire; indeed the shock on touching the wire became quite sharp when the kite was elevated a few hundred feet, even in a clear sky. *After all, it must be acknowledged that the utility of electricity is yet to be discovered, as also its mode of generation and the part it plays in storms.*
>
> *The evolution of latent caloric* in the formation of cloud is undoubtedly adequate to account for all the phenomena attending storms, with but two or three exceptions noticed before, which may probably be produced by electricity—in a mode, however, not yet exactly known.

In the paragraphs preceding No. 81 there is nothing relative to kite experiments; it seems likely that Espy intended to refer to his Philosophy of Storms and to the kite experiments made by himself and the Franklin Kite Club in Philadelphia. In this case we see that as early as 1836 metallic wire was used instead of string in Philadelphia.

THE KITE USED IN 1822 BY FISHER.

The Editor has several times called attention to the fact that the first to apply the kite to meteorological investigations was the eminent Prof. William Wilson, of Glasgow University, who in 1749 obtained the temperatures at great elevations by means of self-registering minimum thermometers carried up by means of a kite or tandem of kites. In a recent note on this subject by our distinguished co-laborer Mr. G. J. Symons, the learned editor of the Monthly Meteorological Magazine, he states that the next use of the kite for determining temperatures was that made by Rev. George Fisher and Capt. Sir William Edward Parry (at the Island of Igloolik, latitude 69° 21′ N., longitude 81° 42′ W., during Parry's "second voyage" in 1822–23). Mr. Symons quotes the account as published by Harvey, in the Encyclopedia Metropolitana, article, "Meteorology," published in 1834. The experiment by Fisher is one that had long been known to the present Editor, although he was not until now aware of Harvey's reference to it. The original account quoted by Harvey is contained in a letter from Fisher addressed to Dr. Thomas Young as editor of the Quarterly Journal of Science and Arts, published by the Royal Institution of Great Britain (see Vol. XXI, 1826, page 348); it is followed by some notes by Dr. Young, on page 359, both of which we quote as follows:

> WANSTED VICARAGE, ESSEX, *23d Feb.*, 1826.
>
> I have enclosed some of the observations upon the refraction at low temperatures and altitudes, made at the island of Igloolik, N. E. coast of America. And as the law of variation in the temperature of the atmosphere at different heights is connected with the theoretical investigation of the subject, I take the opportunity of mentioning an experiment made by Captain Parry and myself for determining it.
>
> This was done by means of a paper kite, to which was attached an excellent register thermometer, in a horizontal position. Its height above the level of the frozen sea, upon which the experiment was made, was determined by two observers in the same vertical plane, taking its altitude at the same time above the distant horizon; and from thence its height was computed. The greatest height observed was 379 feet, at which height it was nearly stationary for about a quarter of an hour. It probably, however, had been more than 400 feet above the sea. After an unsuccessful attempt, the experiment was made under very favourable circumstances, the kite being sent up and caught in coming down, without the slightest shake. The indices had not altered their position in the slightest degree, and they would have indicated any variation of temperature, had it existed, to less than a quarter of a degree Fahr. The temperature at the time was —24° Fahr.
>
> I have also enclosed Dr. Brinkley's table of refractions, adapted to temperatures as low as —50° Fahr., which he was kind enough to send me.
>
> From, Dear Sir, yours truly. GEO. FISHER.

Note on the above by Dr. Thomas Young on page 359:

> The observations of Mr. Fisher and of Mr. Foster fully justify the remark already made in the thirteenth number of these collections, (Vol. XV, p. 128), that the refractions at low temperatures, as indicated by Dr. Young's table, which are found to be somewhat greater than those which Mr. Groombridge has observed in this country, would probably be found to be less in *excess* when applied to colder climates. That they would, however, have been actually so much in *defect* as these observations have demonstrated, could not have been foreseen without actual trial. The theory is indeed greatly illustrated by Mr. Fisher's very valuable experiment with the kite, which shows that the law of decrease of temperature must be supposed to be very differ-

ent in the arctic regions from that which prevails in more moderate latitudes; but it serves fully to prove the impossibility of forming any hypothesis respecting the constitution of the atmosphere which shall be universally correct.

Following the above Dr. Young gives some notes as to the effect of a change of a degree Fahrenheit on the astronomical refraction.

Shortly after this time, viz, in the Edinburgh Journal of Science, 1827, Vol. VI, page 246, Sir Thomas Brisbane quotes Fisher's experiments and Dr. Young's remarks in connection with observations made at Port Macquarie, Van Diemens Land, in June, 1824, at an upper and lower station, for the purpose of determining the decrease of temperature with altitude.

In the Edinburgh Journal for January, 1827, Vol. VI, p. 146, Brewster, as editor, commenting on the hourly observations proposed by the Royal Society of Edinburgh, used the following words:

To those meteorologists who have sufficient leisure and the means of performing such experiments, we would recommend the use of kites or of balloons for ascertaining the temperature and state of the upper atmosphere. The Earl of Minto has obtained several very interesting results by the use of balloons.

The observations by the Earl of Minto here referred to were given in the subsequent volume, page 249, where it appears that small captive balloons were used up to a height of 1,340 feet. An observer ascended with the balloon; the height was varied frequently by letting out or pulling in the line. The rise of temperature after sunset at the upper station was well established.

Another account of the experiment by Rev. George Fisher is given at page 187 of the volume of scientific memoirs published at London, 1825, as the Appendix to Captain Parry's Journal of the Second Voyage for the Discovery of the Northwest Passage. In the Appendix No. 2, on Atmospheric Refraction, on page 187, Mr. Fisher says:

It appears by an experiment that when the sea is covered with ice in the winter there is no sensible difference between the temperatures of the atmosphere at the surface of the ice and at the height of 400 feet above it. This was tried by means of a paper kite with an excellent register thermometer attached to it, the altitude of which was determined by two different observers at the time, at a given distance from each other and in the same vertical plane as the kite, and from which the perpendicular height of the kite above the level of the ice was computed. This experiment was tried under favorable circumstances at a temperature of —24° F. The kite was sent up and caught in coming down without the thermometer being in the least disturbed, the indices of which did not show the slightest alteration although carefully compared before and after these experiments and the kite remained at the same height in the air for a considerable time.

There is nothing to show the special date on which this experiment was made, but it may be safely assumed to have been in February or March, 1823. Whether the upper temperature was lower or higher than that near the earth's surface would have been shown by Mr. Fisher's thermometer, since it appears to have been a self-registering Six thermometer in an iron case, whose two indices would respectively show the maximum and the minimum that occurred during each experiment. Of course the iron case or inclosure which protected this thermometer from accident also greatly increased its sluggishness from a thermometric point of view, and as the thermometer remained at its highest altitude only five or ten minutes, it could not be expected to settle a question of a difference of less than 5° F.

The preceding investigations seem to the Editor to have all been suggested by the active discussion that was in those days going on as to the formula for refraction in the atmosphere, in which Dr. Thomas Young and Mr. Ivory took a prominent part.

ARCHIBALD ON KITES.

A little book has just been published in London, entitled The Story of the Earth's Atmosphere, by Douglas Archibald. This volume contains a very readable, popular account of the general composition, temperature, and circulation of the atmosphere, written by one who has himself contributed something to the progress of meteorology. From Chapter XIII we quote the following. After some remarks on balloons and flying machines, Mr. Archibald says:

When a plane surface is forced through the air, the upward pressure of the air is mostly concentrated near its front edge. If the surface extended far back from the edge, its weight would act at some distance from the front edge. Consequently, the unbalanced pressure of the air would tend to turn the plane over backwards. If, however, its width were small, the weight would act so close to where the resistance acts in the opposite direction that the forces would neutralize each other and stability ensue.

Mr. Hargrave has adopted this principle in his cellular or box kite, whose construction is sufficiently obvious to render detailed description unnecessary.

The dimensions are as follows: The length of each cell (from right to left) is 30 inches, and the width and height and opening between are about 11 inches; but these dimensions may vary so long as the two cells together form a nearly square area. An important feature of this peculiar, tailless kite consists of the covered-in sides. These ensure stability even better than two planes bent upward in V shape, such as the wings of the kestrel when hovering, and they prevent the kite from upsetting, very much as the sides of a ship give it stability.

Mr. Maxim once showed the advantage of such side planes by a simple experiment in which a piece of paper, when held horizontally and let fall to the floor, is seen to execute a series of zigzags in the air, frequently ending in its complete overthrow; whereas when the same piece of paper is folded up round the edges like a boat, it sails to the floor quite evenly and in a straight line. * * *

The *kite* was first invented by the Chinese General Han Sin in 206 B. C., for use in war, and was frequently employed after that date in China by the inhabitants of a besieged town to communicate with the outside world. After this kites appear to have degenerated into mere toys.

At the middle of the present century, however, Pocock of Bristol employed them to draw carriages, and is said to have traveled from Bristol to London in a carriage drawn by kites. They were also occasionally employed to measure the temperature of the upper air, by Admiral Back, on the *Terror*, and Mr. Birt, at Kew, in 1847.

These observations had been quite forgotten when the author first suggested the employment of kites for systematic observations in 1883. It has since been discovered that Dr. Wilson, of Glasgow, as long ago as 1749, resuscitated kites from their long burial with a similar idea of employing them to measure temperature.

In the author's experiments, steel wire was first employed to fly them with. Two kites of diamond pattern, made of tussore silk and bamboo frames, were flown tandem, and four self-recording Biram anemometers, weighing 1¼ pounds each, were attached at various points up the wire. Heights from 200 to 1,500 feet were reached by the instruments, and the increase of the average motion of the atmosphere was measured on several occasions for three years. Kites were also employed first, by the author, in 1887, to photograph objects below by means of a camera attached to the kite wire, the shutter being released by explosion. Since that time kite photography has leapt into popularity and has been successfully practised by M. Batut, in France, Capt. Baden Powell, in England, and Eddy, in New Jersey. * * *

It was further suggested by the author, in 1888 (Les Cerfs Volants Militaires. Bibliothèque des Connaissances Militaires. Paris, 1888.), that kites could be used for various purposes in war as well as science.

Since then Capt. Baden Powell, in May, 1895, read a paper on "Kites, their uses in War." In both these publications it was pointed out that kites possessed several distinct advantages over balloons; next, that they could be applied to all the purposes for which balloons could be employed, such as signalling, photography, torpedo projection, carrying despatches between vessels, and, lastly, they could be employed to raise a man for purposes of reconnaissance.

EFFICIENCY OF WINDMILLS.

In his Story of the Earth's Atmosphere, Mr. Douglas Archibald, says:

It is estimated that there are more than a million windmills in the United States alone. The useful efficiency of windmills, especially in the modern geared form, is comparable with that of the best simple steam engines.

A geared modern wheel, 20 feet in diameter, will develop 5-horse power in an 18 mile an hour breeze, and can be applied to work agricultural machinery and dynamos for electric lighting. With a single wheel of this size Mr. McQeesten, of Marblehead Neck, Mass., U. S.

A., works an installation of 137 electric lights, for which he formerly used a steam engine; as a result he finds that he effects a saving of more than 50 per cent.

According to Lord Kelvin, wind still supplies a large part of the energy used by man. Out of 40,000 of the British shipping, 30,000 are sailing ships, and as coal gets scarcer "wind will do man's work on land, at least in proportion comparable to its present doing of work at sea, and windmills or wind motors will again be in the ascendant."

THE FRANKLIN KITE CLUB AND JAMES SWAIM.

In the American Journal of Science for 1837, Vol. XXXII, pp. 304–307, there is an article by James Swaim (b. 1816, d. 1877), describing some observations by himself, made October and November, 1836, for the purpose of determining daily the height of that layer of electrified air "whose positive electricity was concentrated enough to expand the leaves of the electrometer." Such measurements would of course determine the height of a layer having a constant difference of potential with regard to the earth's surface at the lower end of the wire. Mr. Swaim used a kite and apparatus which he describes as follows:

> The preceding experiments were made with common three-stick kites, two feet six inches long and two feet four inches wide, tapering from the middle to the top. Wire No. 30 was used, which was wound on a reel four feet in circumference, having a glass axle running on a frame about three feet high, which was made in the same manner as the one used by the Franklin Kite Club of Philadelphia.
>
> An electrometer was connected with an iron ring through which the wire passed, and which was suspended by means of silk in front of the reel for the purpose of preventing the wire from running off in winding up rapidly.
>
> Also an instrument was used for finding the height of the kite, which I constructed in the following manner: Two stationary arms of different lengths were placed at right angles. The longer of these was graduated into small equidistant divisions. A movable arm, which was graduated in the same manner, was attached to the short arm, into which was let a level. This instrument was attached to the front of the reel stand by means of a screw, on which it could move.

The height of the kite was found by means of a simple proportion. Mr. Swaim also publishes the meteorological observations made by him at the surface of the earth, concerning which he says:

> The dew-point was found from the following formula, discovered by Mr. Espy: Take two thermometers (Fahrenheit) that agree, or allow for the difference; cover one of the bulbs with a wet rag and suspend them in the shade where there is a draft of air, or fan them briskly until they become stationary. Then the difference of the thermometers being multiplied by one hundred and three, the product divided by the number of degrees indicated by the wet bulb, and the quotient subtracted from the number of those indicated by the dry one, will give the dew-point.

From the above we infer that wire was used both by the Franklin Kite Club before 1836, and by Mr. Swaim in that year. The "three-stick kites" described by him are sometimes called "house kites," and have the form of an irregular but symmetrical hexagon.

The reference to Espy's use of the "whirled psychrometer" is important as confirming the conclusion long since published by the Editor, that Espy was the first who practiced this use of the instrument.

KITES IN AMERICA AND EUROPE.

The active meteorologists of to-day with their abundance of scientific periodicals do not easily realize the difficulties under which our ancestors labored a century ago. Before the establishment of Silliman's American Journal of Science, 1818, and the Franklin Journal, or the Journal of the Franklin Institute by Dr. Jones in 1826, Americans necessarily looked to England and France for the records of the progress of science. The journals that were most widely circulated among us were Tilloch's Philosophical Magazine, Nicholson's Journal of Natural Philosophy, Phillip's Annals of Philosophy, Brewster's Edinburgh Journal of Science, and Young's Quarterly Journal of Science, and in these we must search, not only for American contributions, but also for the articles that stimulated American workers and the ideas that were prevalent among them. The modern application of the kite to meteorological work illustrates very prettily this interchange of ideas between Great Britain and America. Franklin and his electric kite of 1748 were but tales of the past when, in 1825, the memoir of Prof. Alexander Wilson (which had lain neglected for thirty-six years among the papers of his son, Prof. Patrick Wilson) was published in the Transactions of the Royal Society of Edinburgh, and almost at the same time was largely reprinted in Thomson's Annals of Philosophy for November, 1826 (apparently the last volume before the Annals were united with the Philosophical Magazine). An abstract of this paper was published as promptly as possible in the Franklin Journal for March, 1827, Vol. III, p. 182, and must have at once fallen into the hands of Espy, who was at that time studying meteorological matters. About this time, also, he must have read Fisher's article in the Quarterly Journal for 1826, and soon began his own experiments with kites. He must, also, have seen Harvey's article in the Encyclopedia Metropolitana in 1834, as that encyclopedia was widely circulated in the United States. Espy's theories as to atmospheric currents and storms, the temperature of the air, and the formation and heights of clouds, supported as they were by his own observations with kites and those of the Franklin Kite Club, excited much attention in Europe between 1835 and 1845. The discussions on his theories preceded, if they did not directly lead to, the attempt of Birt and Ronalds in 1847 at the Kew Observatory to determine the real condition of the atmosphere above us as to temperature and moisture. Their experiments were given up as unsatisfactory and the kite seems to have been abandoned—if I may except some observations of my own in 1867 at Washington and 1876 at Atlantic City and those of Van Rysselbergh in Belgium in 1880—until Archibald began his valuable work in England in November, 1883. The scanty use made of the kite during this interval resulted very largely from the fact that the balloon had absorbed attention and, indeed, seemed at first to offer all the facilities needed for the exploration of the upper air. Afterwards balloon work was supplemented by the establishment of mountain stations, beginning with Mount Washington, 1870, and Pikes Peak, 1873. But the progress of dynamic meteorology had shown the need of regular observations from stations that are more perfectly isolated from terrestrial influences than is possible on a mountain top. The Eifel tower seemed to perfectly respond to our needs, but such towers are expensive and rare. A few isolated investigations by no means respond to the needs of dynamic meteorology. The work done with balloons, kites, and mountain stations was reviewed in my lectures of 1882–85, showing that we must have maps of the upper isobars, isotherms, and winds and, to this end, must increase the number of our mountain stations and stimulate the use of balloons. In June, 1885, Mr. McAdie used kites to study atmospheric electricity at Blue Hill in extension of his studies under Professor Trowbridge at Cambridge. In my official estimates of July, 1885, and September, 1886, respectively, I included "kites, wire, reels, and sextant for the study of wind pressure" and, again, "kites, etc., for the study of temperature and wind at moderate elevations," as supplementary to balloons and mountain stations. But the important stimulus was given to this kite work by Eddy at Bayonne, N. J., in 1890, and just at this opportune moment Hargarve, in 1893, at Sydney, Australia, contributed to the progress of science his unique and valuable cellular kite, a full account of which was read at the Columbian Exposition, Chicago, 1893. Since then Eddy's work has been carried forward at Blue Hill by Mr. Rotch and his assistants, while

Hargrave's work has been taken up at Washington under Professor Moore's instructions and perfected by Potter and Marvin. At the same time the Germans have been busy developing a combination balloon and kite, powerful enough to carry up an officer for the purpose of military reconnaissances. Each successive decade of this century has witnessed a series of personal experiments in Europe and America, until now, just as the European meteorological bureaus have taken up the sounding balloon as a means of exploration to great vertical altitudes, the United States Weather Bureau has prepared kites to cover a great horizontal extent of territory with automatic meteorological instruments. The American system of kite work contemplates regular daily records with kites at about 5,000 feet altitude, while the European system is designed for special occasional work at 50,000 feet altitude. Undoubtedly each will supplement the other.

FURTHER COMMENT IS UNNECESSARY.

The Weather Bureau notes articles in two Boston papers, The Happy Thought, March 20, and The Transcript, April 28, which purport to be reports of papers read by the Director and staff of the Blue Hill Observatory before the Boston Scientific Society. The animus of these papers is to eulogize unduly the original work of that observatory at the expense of the United States Weather Bureau. The Blue Hill Observatory is entitled to much credit for its contributions to science, and its Director deserves all praise for his zeal in the advancement of meteorology, but we regret to say that several statements in the above articles are very misleading and incorrect, as shown by well known facts in the history of the National Service. If the Director of the Blue Hill Observatory thinks it necessary to thus magnify his own work, we respectfully suggest that it be done in such a way as to be above the criticism of his friends.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation; the altitudes of the instruments, the total depth of snowfall, and the mean wet-bulb temperatures are now given.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (....).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, total depth of snowfall, and the respective departures from normal values. Reports from Newfoundland and Bermuda are included in this table for convenience of tabulation.

Table IV gives detailed observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, meteorologist to the Government Survey.

Table V gives, for 26 stations, the mean hourly temperatures deduced from thermographs of the pattern described and figured in the Report of the Chief of the Weather Bureau, 1891–'92, p. 29.

Table VI gives, for 26 stations, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use. Both instruments are described in the Report of the Chief of the Weather Bureau, 1891–'92, pp. 26 and 30.

Table VII gives, for about 130 stations, the arithmetical means of the hourly movements of the wind ending with the respective hours, as registered automatically by the Robinson anemometer, in conjunction with an electrical recording mechanism, described and illustrated in the Report of the Chief of the Weather Bureau, 1891–'92, p. 19.

Table VIII gives, for all stations that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions based on these two observations only and without considering the velocity of the wind. The total movement for the whole month, as read from the dial of the Robinson anemometer, is given for each station in Table I. By adding the four components for the stations comprised in any geographical division one may obtain the average resultant direction for that division.

Table IX gives the total number of stations in each State from which meteorological reports of any kind have been received, and the number of such stations reporting thunderstorms (T) and auroras (A) on each day of the current month.

Table X gives, for 56 stations, the percentages of hourly sunshine as derived from the automatic records made by two essentially different types of instruments, designated, respectively, the thermometric recorder and the photographic recorder. The kind of instrument used at each station is indicated in the table by the letter T or P in the column following the name of the station.

Table XI gives a record of rains whose intensity at some period of the storm's continuance equaled or exceeded the following rates:

Duration, minutes..	5	10	15	20	25	30	35	40	45	50	60	80	100	120
Rates pr. hr. (ins.)..	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.86	0.84	0.75	0.60	0.54	0.50

In the northern part of the United States, especially in the colder months of the year, rains of the intensities shown in the above table seldom occur. In all cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest rainfall of any single storm has been given, also the greatest hourly fall during that storm.

Table XII gives the record of excessive precipitation at all stations from which reports are received.

NOTES EXPLANATORY OF THE CHARTS.

Chart I.—Tracks of centers of high pressure. The roman letters show number and order of centers of high areas. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the 8 a. m. and 8 p. m., seventy-fifth meridian time, observations. The queries (?) on the tracks show that the centers could not be satisfactorily located. Within each circle is given the highest barometric reading reported near the center. A blank indicates that no reports were available. A wavy line indicates the axis of a ridge of high pressure.

Chart II.—Tracks of centers of low pressure. The roman letters show number and order of centers of low areas. The

figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the 8 a. m. and 8 p. m., seventy-fifth meridian time, observations. The queries (?) on the tracks show that the centers could not be satisfactorily located. Within each circle is given the lowest barometric reading reported near the center. A blank indicates that no reports were available. A wavy line indicates the axis of a trough or long oval area of low pressure.

Chart III.—Total precipitation. The scale of shades showing the depth of rainfall is given on the chart itself. For isolated stations the rainfall is given in inches and tenths, when appreciable; otherwise, a "trace" is indicated by a capital T, and no rain at all, by 0.0.

Chart IV.—Sea-level isobars, surface isotherms, and resultant winds. The wind directions on this Chart are the computed resultants of observations at 8 a. m. and 8 p, m., daily; the resultant duration is shown by figures attached to each arrow. The temperatures are the means of daily maxima and minima and are not reduced to sea level. The pressures are the means of 8 a. m. and 8 p. m. observations, daily, and correspond to Professor Hazen's system of reduction; the barometer is not reduced to standard gravity, but the necessary reduction for 30 inches of the mercurial barometer is shown by the marginal figures for each degree of latitude.

Chart V.—Total snowfall, with the isotherms of minimum 32° F., and minimum 40° F.

Chart VI.—Hydrographs for seven principal rivers of the United States.

TABLE I.—*Climatological data for Weather Bureau Stations, April, 1897.*

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.								
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Mean actual, 8 a. m. and 8 p. m. + 2.	Mean reduced.	Departure from normal.	Mean max. and min. + 2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.
New England.																														
Eastport		76	69	74	29.94	30.03	+ .04	44.6	+ 1.6										4.62	+ 0.7									
Portland, Me		103	81	89	29.91	30.01	+ .09	38.6	0.0	59	29	45	15	20	32	22	36	32	3.35	+ 0.3	17	7,886	sw.	41	s.	19	10	5	15	6.3	11.0
Northfield		872	15	59	29.10	30.06	+ .10	43.8	+ 2.2	71	30	32	12	20	30	32	39	34	2.73	+ 0.5	14	6,635	s.	32	s.	19	10	10	10	5.1	2.4
Boston		125	115	181	29.92	30.06	+ .13	41.3	+ 2.6	82	25	32	21	20	40	32	43	36	2.60	— 0.4	11	5,853	s.	36	sw.	19	5	12	13	6.5	5.7
Nantucket		14	43	54	30.08	30.09	+ .13	49.0	+ 3.9	81	35	38	26	20	39	32	42	40	2.73	+ 0.5	14	6,486	sw.	36	sw.	19	11	9	10	5.0	T.
Woods Hole			51	57				44.2	+ 2.0	61	30	49	26	20	39	32			3.17	— 0.3	12	8,486	sw.	36	sw.	19	11	9	10	5.0	T.
Vineyard Haven			30					44.4	+ 0.1	65	30	50	26	20	39	32			4.47	+ 0.9	10	8,039	sw.	31	n.	20	13	6	11	5.5	T.
Block Island		27	39	48	30.07	30.10	+ .15	48.0	+ 1.4	70	35	56	28	20	40	33			5.73	+ 1.7	9	10,782	s.	46	sw.	19	16	9	5	3.5	T.
Narragansett Pier			10					44.2	+ 0.4	62	30	50	26	20	40	33			5.95	+ 3.0	9										T.
New Haven		107	118	140	29.97	30.09	+ .12	45.2	+ 1.0	68	30	54	19	20	39	32	41	38	5.70	+ 2.3	7	10,526	sw.	40	sw.	19	9	17	4	4.6	
Mid. Atlan. States.								47.8	+ 2.0	73	30	57	24	20	38	34			4.10	+ 0.5	9										
Albany		97	84	113	29.98	30.09	+ .13	52.2	+ 0.8								42	36	2.44	— 1.1	7	7,185	sw.	38	nw.	26	10	6	14	5.2	T.
Binghamton		875	79	90				48.0	+ 1.3	83	25	58	21	20	38	34	41	35	2.63	— 0.6										
New York		314	298	326				45.9		82	25	57	18	20	35	37			3.12	+ 0.6	13	6,460	s.	36	se	13	7	8	15	6.2	T.
Harrisburg		377	94	102	29.76	30.10	+ .12	48.6		82	25	57	24	20	41	34	42	36	1.98		9	5,483	nw.	36	s.	13	8	12	10	5.8	0.4
Philadelphia		117	168	184	29.71	30.13	+ .13	50.8	+ 0.7	84	25	61	26	20	43	34	43	34	2.96	— 0.4	9	9,696	nw.	58	nw.	27	15	9	6	4.2	T.
Atlantic City		52	68	76	29.99	30.12	+ .13	52.6	+ 2.0	85	25	63	27	20	45	35	45	38	2.53	— 0.9	9	5,581	nw.	34	sw.	19	7	13	10	5.8	T.
Baltimore		123	68	82	30.07	30.12	+ .15	48.4	+ 1.3	69	26	55	28	20	42	35	45	38	3.03	0.0	8	7,817	nw.	37	nw.	26	14	7	9	4.9	
Washington		112	59	76	29.98	30.11	+ .11	53.0	+ 0.1	84	25	63	29	20	43	38	45	41	3.42	+ 0.1	8	8,502	sw.	37	nw.	26	14	7	9	4.9	
Cape Henry			5	34				52.9	+ 0.1	88	25	64	29	20	42	37	45	36	3.19	— 0.2	10	3,974	w.	29	nw.	26	12	11	7	4.3	
Lynchburg		668	83	88	29.41	30.15	+ .15	54.9	+ 0.1	88	25	68	34	21	47	33	46	38	3.02	— 0.3	11	5,599	s.	35	nw.	26	12	11	7	4.5	
Norfolk		57	88	93	30.09	30.15	+ .15	55.6	— 0.2	88	25	68	30	21	43	38	47	40	1.47	— 3.0	8		se.			9	16	8	6	4.0	
S. Atlantic States.								57.5	+ 1.4	87	25	67	34	21	48	31	51	47	2.08	— 1.3	10										
Charlotte		773	67	76	29.28	30.10	+ .09	62.0	0.5										1.51	— 2.6	9	3,570	nw.	26	nw.	9	14	11	5	4.4	
Hatteras		11	17	26	30.15	30.16	+ .16	59.6	— 0.2	86	29	70	35	21	49	31	50	42	3.14	— 0.5		6,332	se.	30	sw.	9	16	9	5	4.0	
Kittyhawk		9	12	30	30.12	30.13	+ .14	57.0	— 0.3	75	30	63	39	21	52	30	53	50	3.94	+ 0.4	10	5,334	s.	36	sw.	9	16	7	7	4.1	
Raleigh		375	98	101	29.74	30.15	+ .14	55.4	+ 0.6	82	25	63	35	21	47	32	53	48	2.76	— 2.0	8	8,752	ne.	44	n.	20	12	10	8	4.8	
Wilmington		78	82	88	30.06	30.15	+ .14	60.0	+ 2.5	86	25	71	32	2	49	32	52	48	1.35	— 3.1	4	10,829	ne.	48	sw.	9	14	10	6	3.9	
Charleston		48	60	72	30.11	30.16	+ .14	61.4	+ 0.1	84	25	70	35	21	52	28	55	52	4.66	+ 2.1	11	4,874	sw.	26	sw.	9	14	10	6	4.3	
Columbia			5					65.6	+ 1.4	92	6	72	49	2	60	17	59	56	2.17	— 0.8	11	6,419	s.	44	sw.	9	15	11	4	3.8	
Augusta		180	89	108	29.92	30.11	+ .11	62.7	— 0.3	87	29	74	39	21	51	34	55	50	1.89	— 1.7	11	8,733	s.	44	ne.	1	16	10	4	3.9	
Savannah		98	63	86	30.02	30.13	+ .08	63.4	— 0.9	88	28	74	42	11	52	34	59	56	2.32	— 0.4	9		nw.								
Jacksonville		43	69	84	30.06	30.11	+ .07	66.2	+ 0.1	85	6	75	45	11	58	24	63	61	3.75	+ 0.4	11	4,651	se.	38	sw.	29	14	8	8	....	
Florida Peninsula.								69.0	+ 0.2	88	28	78	44	11	60	25	63	61	3.35	— 0.1	11	6,895	s.	36	ne.	1	15	5	10	4.7	
Jupiter		28	13	30	30.06	30.09	+ .05	72.4	— 1.2										5.18	+ 2.3	12	6,100	se.	46	s.	9	9	13	8	5.0	
Key West		22	42	50	30.06	30.08	+ .04	71.5	— 2.3	83	16	77	59	11	66	20	66	63	5.86	+ 4.0										
Tampa		36	60	68	30.06	30.10	+ .05	75.5	— 0.5	84	9	80	66	17	71	15	69	66	8.47	+ 6.0	15	8,890	ne.	39	sw.	6	4	10	16	6.9	
East Gulf States.								70.3	— 0.8	86	27	79	47	11	61	28	64	60	4.45	+ 3.2	6	8,810	ne.	36	n.	7	7	15	8	5.7	
Atlanta		1,131	92	126	28.93	30.12	+ .08	65.3	— 1.6										4.65	+ 2.8	7	5,631	ne.	36	se.	6	10	13	7	5.0	
Pensacola		56	78	90	30.03	30.09	+ .05	59.8	— 1.8	84	28	69	38	10	50	26	61	58	5.65	+ 1.3										
Mobile		57	88	96	30.03	30.09	+ .06	66.4	— 1.4	85	30	73	46	10	60	27	67	63	5.06	+ 1.4	9	7,734	nw.	48	w.	8	14	6	10	4.6	
Montgomery		221	100	107	29.85	30.09	+ .05	65.6	— 2.0	82	27	74	45	18	58	28	60	56	3.08	— 0.4	11	7,834	s.	38	s.	3	5	17	8	5.8	
Vicksburg		254	65	73	29.78	30.09	+ .04	64.0	— 1.9	88	27	74	42	11	54	35	57	53	5.73	+ 1.0	11	6,158	se.	28	nw.	8	14	9	7	4.8	
New Orleans		54	112	120	30.02	30.08	+ .07	65.2	— 1.4	84	*	74	45	10	56	27	57	51	6.30	+ 1.5	11	5,010	se.	29	e.	1	17	6	7	4.2	
Port Eads			27					68.0	— 1.5	84	4	75	50	10	61	33	61	58	1.96	— 3.9	8	5,494	se.	30	nw.	9	20	8	2	2.5	
West Gulf States.								68.0	— 1.4	79	29	73	53	10	63	18			5.75	+ 0.6	9	6,925	se.	36	w.	8	3	13	14	6.8	
Shreveport		249	77	84	29.78	30.04	+ .06	66.4	— 0.6										11.70	+ 8.7	6		e.					12	6	12	....	
Fort Smith		481	63	72	29.51	30.02	+ .07	66.0	— 1.6	84	26	76	44	10	56	30	57	52	2.38	— 1.5										
Little Rock		302	71	79	29.74	30.06	+ .07	61.7	— 0.6	84	27	73	39	*	51	34	54	48	1.71	— 3.5	8	5,740	se.	30	e.	6	11	7	12	5.4	
Corpus Christi		20	42	50	30.01	30.03	+ .05	61.8	— 1.0	83	27	71	42	10	53	30	53	47	3.17	— 1.9	13	5,830	e.	36	sw.	28	14	8	8	4.5	
Galveston		42	85	96	30.08	30.07	+ .08	70.4	+ 0.3	83	30	75	52	9	66	27	66	63	5.88	+ 1.1	13	5,917	nw.	30	nw.	8	9	10	11	5.3	
Palestine		510	54	61	29.51	30.05	+ .06	69.4	— 0.4	81	3	74	50	9	65	28	64	62	0.83	— 0.8	7	10,129	se.	36	n.	14	9	13	8	5.0	
San Antonio		704	96	104	29.29	30.03	+ .06	66.1	— 0.4	86	4	77	41	9	55	26	57	51	1.24	— 1.6	5	8,382	se.	46	n.	14	15	11	4	3.6	
Ohio Val. & Tenn.								69.2	— 0.3	92	7	80	45	9	58	36	59	52	1.84	— 1.1	5	7,425	se.	46	n.	8	8	14	8	5.7	
Chattanooga		762	106	112	29.31	30.12	+ .10	54.9	— 0.6										4.58	+ 0.5										
Knoxville		980	80	88	29.07	30.11	+ .09	59.5	— 1.3	85	28	70	36	11	49	34	51	44	4.18	+ 0.4	12	5,810	s.	37	sw.	8	9	13	8	5.3	
Memphis		399	140	154	29.64	30.07	+ .08	58.6	0.0	85	28	70	34	11	48	38	51	45	6.26	+ 1.3	13	4,235	w.	31	sw.	29	12	7	11	4.9	
Nashville		545	128	134	29.50	30.08	+ .10	61.4	— 0.9	84	27	69	42	9	53	30	53	47	5.46	+ 0.1	15	7,853	nw.	40	nw.	25	9	11	10	5.5	
Lexington		989	76	122	29.01	30.08	+ .05	58.4	— 1.2	84	28	68	36	20	49	33	51	44	5.79	+ 1.0	13	6,282	s.	36	se.	1	13	9	8	4.6	
Louisville		525	114	136	29.51	30.09	+ .09	53.2	— 0.1	82	28	62	28	20	44	35	46	39	5.80	+ 2.0	16	9,412	sw.	44	sw.	13	7	9	14	6.3	
Indianapolis		823	154	164	29.19	30.08	+ .09	55.4	— 1.5	86	28	65	28	20	46	40	47	41	3.83	— 0.6	13	7,358	s.	32	s.	13	7	9	14	6.0	
Cincinnati		628	152	157	29.42	30.10	+ .10	50.8	— 1.3	81	28	59	33	20	44	35	46	39	4.83	+ 1.1	13	9,049	nw.	43	sw.	13	9	7	14	6.0	
Columbus		834	87	100	29.20	30.09	+ .10	52.4	— 1.3	81	28	61	26	20	42	34	45	40	3.08	— 0.1	13	6,749	nw.	36	w.	16	10	8	12	5.6	0.1
Pittsburg		842	116	126	29.20	30.11	+ .11	50.6	— 0.1	82	24	59	33	20	42	34	46	42	4.27	+ 1.1	13	6,194	sw.	33	ne.	1	4	7	19	7.0	T.
Parkersburg		638	77	84	29.43	30.12	+ .12	51.0	+ 0.1	81	24	60	36	20	42	41	46	39	3.34	+ 0.5	15	5,053	w.	34	se.	30	4	14	12	6.2	0.1
Lower Lake Region.								52.9	+ 0.9	83	24	63	38	20	42	41	46	39	3.56	+ 0.2	12	4,632	se.	36	nw.	25	4	14	12	6.4	
Buffalo		768	178	206	29.24	30.08	+ .10	45.5	+ 1.3										3.04	— 0.3										
Oswego		335	76	87	29.69	30.07	+ .08	44.2	+ 2.9	74	29	53	21	19	36	32	38	32	2.56	+ 0.1	18	11,002	sw.	54	w.	19	4	12	14	6.7	2.7
Rochester		523	81	90	29.50	30.08	+ .08	44.0	+ 2.0	79	25	52	19	20	37	36	39	34	2.46	+ 0.4	11	8,490	w.	44	s.	13	12	4	14	5.4	1.0
Erie		714	92	102	29.31	30.09	+ .09	45.7	+ 2.5	80	22	55	19	20	36	35	40	35	1.63	— 0.8	15	6,396	sw.	35	w.	19	10	9	11	5.6	5.2
Cleveland		762	190	201	29.25	30.08	+ .11	45.0	+ 1.1	76	22	53	20	20	37	36	40	35	1.55	— 1.0	13	8,782	w.	42	s.	13	10	6	14	6.0	1.0
Sandusky		629	62	74	29.39	30.08	+ .08	46.7	+ 1.8	79	24	55	26	20	39	34	42	38	1.34	— 0.9	13	11,099	s.	49	nw.	19	4	9	17	7.4	0.4
Toledo		674	122	127	29.34	30.07	+ .08	47.0	+ 1.1	81	24	54	25	20	40	33	41	36	2.11	— 0.4	12	7,461	e.	46	nw.	19	3	7	20	7.6	T.
Detroit		730	160	166	29.27	30.08	+ .09	46.4	— 0.3	79	24	55	21	20	38	33	42	37	2.54	+ 0.3	11	8,506	sw.	36	nw.	19	6	7	17	6.8	2.0
Upper Lake Region.								45.2	— 0.8	78	24	53	30	20	37	33	41	36	2.09	— 0.2	12	7,751	se.	37	w.	19	7	6	17	6.7	T.
Alpena		609	61	65	29.39	30.08	+ .08	41.4	+ 1.0										2.93	+ 0.6										
Grand Haven		628	55	64	29.34	30.04	+ .06	39.0	+ 2.0	73	22	47	10	19	32	36	36	33	4.59	+ 2.4	13	7,397	se.	42	sw.	18	6	13	11	6.5	1.7
Marquette		734	67	95	29.32	30.03	+ .03	43.0	— 0.7	76	28	52	18	20	34	32	39	34	3.12	+ 0.6	16	8,826	nw.	37	s.	18	6	11	13	6.5	0.9
Port Huron		639	70	108	29.38	30.09	+ .10	37.8	+ 1.4	73	22	46	9	19	30	33	34	30	2.06	0.0	14	8,296	n.	43	s.	18	6	11	13	6.5	7.5
Sault Ste. Marie		634	58	65	29.36	30.05	+ .02	43.3	+ 2.3	74	22	51	19	20	35	29	39	32	2.01	— 0.1	16	8,667	n.	44	nw.	26	6	11	13	6.1	0.4
Chicago		624	241	274	29.17	30.06	+ .08	36.9	+ 0.4	66	22	46	5	19	27	30	32	27	3.32	+ 1.7	12	7,001	se.	48	nw.	19	8	13	9	5.8	2.7
Milwaukee		671	106	149	29.32	30.06	+ .07	46.0	+ 0.2	78	22	53	24	20	39	31	41	37	2.23	— 0.8	18	14,654	ne.	67	s.	18	11	9	10	5.4	0.9
Greenbay		617	49	57	29.38	30.06	+ .07	43.7	+ 0.5	76	22	51	23	19	37	35	40	37	4.21	+ 1.4	14	8,360	e.	45	sw.	18	4	8	18	7.3	4.5
Duluth		702	95	106	29.26	30.04	+ .04	43.0	+ 1.1	75	22	51	17	19	35	28	38	33	4.09	+ 1.9	11	7,339	n.	40	sw.	19	10	12	8	5.6	2.2
North Dakota.								40.0	+ 1.8	73	22	51	14	19	32	40	35	29	0.72	— 1.7	9	8,458	ne.	44	sw.	22	15	11	4	4.0	T.
Moorhead		935	54	60	29.00	30.04	+ .06	43.4	+ 4.4	90	27	54	16	19	34	40	38	35	1.16	— 0.8										
Bismarck		1,674	16	29	28.25	30.06	+ .09	44.3	+ 1.8	81	26	52	19	19	32	43	36	30	0.92	— 1.3	6	8,891	nw.	44	nw.	18	3	16	11	6.5	
Williston		1,875	15	31	28.00	30.02	+ .05	42.2	0.0	80	26	54	20	2	34	51	38	31	1.40	— 0.9	10	7,657	nw.	47	nw.	18	10	8	12	5.9	3.0
Upper Miss. Valley.								43.8	+ 0.9	90	26	54							1.17	— 0.2	10	7,712	n.	48	n.	18	10	16	4	5.0	2.5
Minneapolis		99						50.0	+ 0.7										3.82	+ 0.3										
St. Paul		837	114	124	29.10	30.02	+ .05	46.4	+ 0.7	78	27	56	21	19	36	32			1.48	— 1.3	9		ne.							
La Crosse			70	78				45.8	— 0.1	78	27	55	23	19	37	34	39	31	1.56	— 0.9	11	6,820	nw.	40	nw.	18	8	10	12	....	0.5
Davenport		599	71	79	29.36	30.02	+ .04	46.4	— 0.7	75	22	56	22	19	37	36			1.86	— 0.4	9	7,064	n.	36	nw.	18	9	12	9	5.4	4.6
Des Moines		867	84	88	29.10	30.04	+ .06	49.0	— 0.4	78	22	57	28	20	41	40	43	37	3.69	+ 0.9	13	7,240	e.	38	sw.	18	6	6	18	7.0	0.2
Dubuque		698	49	56	29.26	30.03	+ .06	49.4	— 1.0	79	27	58	29	19	40	41	44	38	7.37	+ 4.6	13	7,906	nw.	44	sw.	22	10	9	11	5.6	T.
Keokuk		614	64	78	29.36	30.03	+ .07	47.6	— 0.8	77	22	56	25	19	40	42	42	36	3.39	+ 0.6	12	6,704	nw.	36	nw.	19	13	5	12	5.1	T.
Cairo		359	87	93	29.66	30.05	+ .08	51.3	— 0.8	80	22	59	32	*	44	38	46	42	3.54	+ 0.3	12	7,505	sw.	36	sw.	23	7	11	12	6.2	
								57.8	— 0.8	80	26	65	36	9	50	26	52	46	6.49	+ 2.6	15	7,959	s.	36	nw.	25	7	11	12	5.9	

TABLE I.—*Climatological data for Weather Bureau Stations, April, 1897*—Continued.

Stations.	Elevation of instruments: Barometer above sea level, feet.	Thermometers above ground.	Anemometers above ground.	Pressure, in inches: Mean actual, 8 a. m. and 8 p. m. + 2.	Mean reduced.	Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max. and min. + 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches: Total.	Departure from normal.	Days with .01, or more.	Wind: Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.
Up. Miss. Val.—Con																															
Springfield, Ill	644	82	92	29.35	30.05	+ .06	50.6	— 2.5	77	28	58	28	20	43	37	45	39	70	3.85	+ 0.1	15	8,899	nw.	36	se.	12	4	9	17	7.2	0.1
Hannibal	534	75	107	.....	.....	.....	52.9	.....	80	21	61	33	20	45	33	....	....	....	3.96	+ 1.3	13	9,061	sw.	44	sw.	18	7	12	11	5.7	
St. Louis	567	111	210	29.45	30.07	+ .10	56.0	— 0.7	80	28	64	35	8	48	32	50	46	78	4.66	+ 0.9	14	9,050	s.	43	e.	3	7	7	16	6.2	T.
Missouri Valley.							50.8	— 0.9											4.11	+ 1.1											
Columbia	.....	4	84	.....	.....	.....	55.4	— 0.6	84	27	66	29	17	44	38	....	....	....	4.83	+ 0.3	12	8,491	se.	44	e.	28	6	9	15	6.8	
Kansas City	963	78	95	29.00	30.04	+ .08	54.7	0.0	84	18	64	35	19	46	35	47	40	64	2.57	— 0.4	7	7,865	s.	36	s.	21	8	11	11	6.0	
Springfield, Mo	1,324	100	103	28.62	30.03	+ .06	54.9	— 2.2	81	27	64	34	9	46	30	47	41	66	3.73	— 0.2	13	9,355	se.	36	se.	21	8	18	4	4.7	
Topeka	.....	81	....	.....	.....	.....	55.0	— 0.3	86	18	66	35	9	44	42	....	....	....	2.44	+ 0.2	13	.....	nw.	....	.....	....	10	11	9	....	
Lincoln	1,199	74	84	28.71	30.00	.....	50.0	— 1.4	80	21	60	30	19	40	36	46	43	80	6.15	+ 4.0	13	10,582	nw.	50	n.	28	9	11	10	5.2	
Omaha	1,108	92	97	28.82	30.00	+ .02	50.5	— 0.9	79	27	59	29	19	42	35	46	42	77	5.67	+ 2.5	14	7,489	nw.	35	nw.	22	9	9	12	5.9	
Sioux City	1,139	96	109	.....	.....	.....	47.6	— 1.9	79	27	58	24	19	37	42	....	....	....	4.03	+ 1.0	15	11,465	n.	54	nw.	18	11	6	13	5.9	
Pierre	1,460	50	61	28.44	30.01	+ .02	46.9	— 0.7	87	27	57	24	19	36	42	40	32	64	3.51	+ 1.6	9	8,156	nw.	46	w.	21	9	9	12	5.8	2.8
Huron	1,310	63	72	28.61	30.04	+ .06	45.4	— 0.4	86	27	56	20	19	35	38	40	36	75	4.03	+ 1.1	15	9,131	n.	48	nw.	18	9	10	11	5.7	T.
Yankton	1,234	51	57	28.69	30.02	+ .05	47.4	— 0.2	80	27	57	24	19	38	40	41	34	67	4.16	+ 1.1	14	8,476	nw.	44	s.	27	13	6	11	5.2	
Northern Slope.							45.1	0.0											1.23	— 0.4											
Havre	2,494	15	33	27.34	29.97	.00	46.6	+ 2.2	83	26	59	26	28	34	39	39	31	62	0.78	— 0.2	6	8,465	w.	48	sw.	26	14	12	4	4.6	1.5
Miles City	2,372	41	49	27.49	30.00	+ .02	47.6	+ 1.0	88	26	58	28	3	38	39	40	32	62	1.69	+ 0.6	8	6,195	w.	36	nw.	21	9	13	8	5.2	....
Helena	4,108	88	93	25.87	30.10	+ .10	45.2	+ 0.3	77	26	54	26	6	36	34	38	28	56	1.15	0.0	11	6,249	sw.	36	ne.	14	12	9	9	4.6	6.2
Rapid City	3,251	53	61	26.62	30.02	+ .01	45.4	0.0	81	26	56	26	3	35	40	37	27	56	0.69	— 1.6	7	6,765	nw.	33	se.	19	7	10	13	6.2	3.9
Cheyenne	6,105	58	60	24.01	30.11	+ .10	40.0	— 3.1	71	26	51	13	3	29	37	32	22	57	0.60	— 0.8	10	8,558	nw.	36	s.	19	12	14	4	4.8	5.2
Lander	5,372	26	36	24.64	30.08	+ .08	42.9	+ 1.0	76	26	56	13	4	30	44	34	23	54	1.14	— 1.2	9	3,435	s.	40	s.	30	9	13	8	5.2	10.5
North Platte	2,826	43	52	27.09	30.06	+ .09	47.8	— 1.6	82	26	59	26	8	37	41	41	36	70	2.59	+ 0.4	10	8,373	nw.	40	nw.	28	8	15	7	5.4	7.2
Middle Slope.							53.2	— 0.5											3.08	+ 1.0											
Denver	5,290	83	151	24.74	30.08	+ .10	47.4	— 0.7	77	26	60	15	1	35	37	38	26	52	1.31	— 0.7	11	6,394	s.	46	sw.	20	9	13	8	4.9	2.2
Pueblo	4,713	74	81	25.26	30.03	+ .09	49.5	— 1.3	81	18	64	17	1	34	45	38	22	44	0.24	— 1.2	4	6,369	nw.	49	n.	28	9	17	4	4.6	T.
Concordia	1,398	42	47	28.50	30.00	+ .02	53.0	— 0.1	85	18	64	30	14	42	41	45	39	66	4.30	+ 2.1	10	7,014	n.	42	s.	21	12	7	11	5.3	
Dodge City	2,504	44	52	27.38	30.00	+ .08	53.8	— 0.3	87	18	66	31	4	41	42	45	38	65	3.21	+ 1.6	7	9,349	nw.	50	n.	28	11	14	5	4.3	
Wichita	1,351	78	85	28.58	30.01	+ .06	56.1	+ 0.3	87	18	67	34	9	45	37	47	40	63	3.66	+ 1.4	10	8,571	n.	40	n.	28	14	6	10	4.7	
Oklahoma	1,218	54	53	28.72	30.02	+ .07	59.6	— 0.8	80	18	71	37	9	48	36	51	45	69	5.87	+ 3.0	9	8,808	n.	44	s.	21	16	11	3	3.7	
Southern Slope.							59.2	— 1.2											0.91	— 0.9											
Abilene	1,749	47	54	28.21	30.04	+ .08	63.1	— 1.0	93	7	75	36	9	51	39	52	44	59	0.74	— 2.0	5	8,667	se.	36	sw.	11	15	7	8	4.1	
Amarillo	3,691	53	61	26.25	30.01	+ .07	55.3	— 1.3	83	7	69	29	9	42	43	44	32	55	1.08	+ 0.2	11	12,557	s.	60	se.	23	12	12	6	4.3	T.
Southern Plateau.							63.1	+ 0.6											0.25	0.0											
El Paso	3,767	10	110	26.15	29.94	+ .01	64.6	+ 0.3	88	18	80	35	1	49	43	45	16	22	0.14	0.0	2	9,083	nw.	60	sw.	2	20	8	2	2.4	
Santa Fe	6,998	47	50	23.25	30.00	+ .05	47.2	— 0.9	72	18	59	24	3	36	33	36	15	36	0.87	+ 0.2	7	5,769	se.	40	nw.	7	16	13	1	3.8	0.2
Phœnix	1,076	47	57	28.75	29.87	.....	68.2	+ 1.0	96	18	85	38	1	52	41	50	31	31	T.	— 0.3	0	3,282	e.	22	sw.	26	26	4	0	1.1	
Yuma	139	16	50	29.74	29.88	— .03	72.4	+ 1.9	100	17	89	42	1	56	43	53	34	32	T.	— 0.1	0	5,159	w.	33	n.	7	24	4	2	1.6	
Middle Plateau.							48.7	— 0.5											0.76	— 0.6											
Carson City	4,720	82	92	25.32	30.09	....	48.9	0.0	78	17	63	25	8	35	45	38	21	40	0.03	— 0.8	3	5,606	sw.	59	w.	6	18	10	2	2.6	0.2
Winnemucca	4,340	59	70	25.73	30.10	+ .12	48.2	+ 0.4	81	17	62	24	8	34	45	38	22	41	0.25	— 0.7	6	7,448	ne.	60	nw.	6	14	5	11	4.5	T.
Salt Lake City	4,344	83	90	25.69	30.12	+ .12	49.0	— 1.8	80	18	60	26	1	38	31	42	35	63	2.00	— 0.2	11	5,215	nw.	40	n.	10	11	8	11	5.0	2.4
Northern Plateau.							49.0	+ 1.5											1.08	— 0.4											
Baker City	3,470	49	47	26.52	30.12	+ .10	47.0	+ 3.0	80	17	59	27	7	35	38	38	27	53	0.64	— 0.6	7	4,730	s.	36	nw.	21	8	14	8	5.2	1.2
Idaho Falls	4,742	10	56	25.29	30.13	+ .13	43.0	+ 1.0	73	26	54	22	13	32	40	38	34	75	1.35	— 0.2	10	6,880	s.	38	s.	10	20	6	4	2.8	4.7
Spokane	1,943	99	107	28.02	30.08	+ .09	50.4	+ 1.3	80	17	62	32	7	39	37	42	32	57	0.60	— 0.8	10	4,376	sw.	36	sw.	10	10	7	13	5.7	
Walla Walla	1,018	65	73	29.02	30.10	+ .10	55.8	+ 0.6	86	18	67	32	11	45	36	47	37	53	1.75	+ 0.2	8	4,760	s.	30	sw.	20	15	9	6	4.2	
N. Pac. Coast Reg.							50.6	+ 1.2											2.82	— 1.8											
Fort Canby	179	10	34	29.95	30.15	+ .11	49.8	+ 1.2	80	15	55	40	2	44	25	46	44	84	2.88	— 2.6	13	8,512	n.	52	s.	21	8	12	10	5.7	
Port Angeles	29	47	61	.....	.....	.....	46.8	+ 1.2	66	25	54	30	27	39	27	....	....	....	0.48	— 1.5	7	4,842	w.	36	w.	10	9	10	11	5.8	
Pysht	.....	5	....	.....	.....	.....	49.2	.....	71	25	59	32	*	39	32	....	....	....	2.75	— 2.3	14	.....	w.	....	.....	...	16	1	13	....	
Seattle	119	100	108	30.03	30.16	.....	52.5	.....	85	16	62	38	27	44	38	46	41	69	1.53	.....	9	3,737	se.	24	sw.	30	12	12	6	4.3	
Tatoosh Island	86	12	21	30.08	30.18	+ .16	47.1	+ 0.1	68	15	51	38	27	43	21	45	42	82	7.61	+ 0.2	14	9,516	e.	55	e.	16	8	8	14	6.4	
Astoria	.....	39	60	.....	.....	.....	51.6	+ 1.9	78	15	59	37	23	44	28	....	....	....	3.14	— 3.1	10	.....	w.	....	.....	...	16	6	8	....	
Portland, Oreg	153	208	213	29.98	30.14	+ .09	55.0	+ 1.8	89	17	66	36	7	44	35	47	39	62	1.76	— 1.5	7	6,153	nw.	34	s.	21	12	13	5	4.0	
Roseburg	521	56	67	29.58	30.14	+ .07	53.2	+ 0.7	90	15	65	33	11	41	43	46	39	67	1.11	— 1.5	7	2,732	nw.	20	nw.	6	14	7	9	4.3	
Mid. Pac. C'st Reg.							57.2	+ 1.8											0.95	— 1.5											
Eureka	64	60	69	30.11	30.17	+ .07	51.0	+ 1.0	72	25	58	36	7	44	27	48	46	87	2.55	— 1.6	8	4,794	nw.	36	nw.	22	9	13	8	4.9	
Redbluff	334	54	58	29.71	30.06	+ .06	63.2	+ 2.7	93	25	76	35	1	51	37	51	38	48	1.22	— 0.9	4	4,921	nw.	34	n.	7	21	7	2	2.3	
Sacramento	71	106	117	.....	.....	.....	62.6	+ 3.1	87	14	74	42	20	51	33	....	....	....	0.25	— 2.0	2	7,223	sw.	39	nw.	22	24	5	1	2.0	
San Francisco	153	161	167	29.94	30.10	+ .06	57.4	+ 1.4	84	24	65	45	2	50	29	51	47	75	0.27	— 1.7	3	8,121	w.	35	w.	30	21	5	4	3.0	
Point Reyes Light	.....	12	....	.....	.....	.....	52.2	+ 1.0	78	9	58	43	1	46	30	....	....	....	0.47	— 1.2	3	.....	nw.	....	.....	...	18	3	9	....	
S. Pac. Coast Reg.							61.5	+ 1.2											0.12	— 1.0											
Fresno	332	67	70	29.67	30.02	.00	63.5	+ 1.5	94	16	78	39	2	49	38	52	42	55	0.30	— 1.0	1	4,018	nw.	26	nw.	22	27	3	0	1.2	
Los Angeles	330	74	76	29.66	30.01	.00	61.2	+ 1.2	90	10	73	40	1	49	35	53	48	73	0.02	— 1.3	1	3,284	w.	24	w.	23	16	12	2	3.1	
San Diego	69	59	70	29.94	30.02	— .01	59.8	+ 0.8	88	9	67	46	3	53	36	53	48	72	0.02	— 0.7	1	3,617	nw.	19	w.	30	23	3	4	2.5	
San Luis Obispo	201	10	46	29.87	30.09	.....	59.6	.....	94	10	74	38	24	45	50	50	44	66	0.18	.....	1	3,833	nw.	21	n.	8	22	4	4	2.8	

NOTE.—The data at stations having no departures are not used in computing the district averages. Letters of the alphabet denote number of days missing from the record. * Two or more directions, dates, or years. † Received too late to be considered in departures, etc.

TABLE II.—*Meteorological record of voluntary and other cooperating observers, April, 1897.*

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Alabama.	°	°	°	*Ins.*	*Ins.*
Alco†	87	39	64.6	5.98	
Ashville†	89	35	61.0	5.00	
Bermuda†	90	38	66.2	5.50	
Birmingham	88	36	64.0	5.09	
Brewton†	87	37	64.2	4.35	
Bridgeport†				4.49	
Citronelle†	84	45	66.6	2.96	
Clanton†	83	38	61.4	1.39	
Cordova†				4.60	
Daphne†	84	42	65.8	6.57	
Decatur†	86	34	60.2	4.55	
Demopolis	88	40	64.5	3.15	
Elba†	88	40	65.4	3.55	
Eufaula *a*†	88	39	63.4	4.28	
Eufaula *c*†				4.78	
Evergreen†	88	40	63.2	3.28	
Florence *a*†				4.44	
Florence *b*†	84	34	61.0	5.00	
Fort Deposit †	88	41	63.7	4.13	
Gadsden	86	36	60.0	3.84	
Goodwater†	91	34	62.3	3.90	
Greensboro†	86	38	62.2	4.24	
Hamilton	90	31	59.2	4.01	
Healing Springs†	90	37	63.4	3.33	
Highland Home†	84	42	64.2	4.07	
Jasper†	85	31	58.8	4.43	
Livingston	85	39	63.9	3.71	
Lock No. 4	85	36	59.7	3.64	
Madison Station†	86	32	59.4	4.85	
Maple Grove	87	29	57.6	4.34	
Marion†	88	42	63.6	4.60	
Mount Willing†	88	40	65.4	5.92	
Newbern†	85	40	63.2	4.27	
Newburg	86	31	60.2	4.90	
Newton†	86	34	62.8	3.55	
Oneonto				3.55	
Opelika†	87	38	63.2	5.37	
Oxanna†	83	34	58.4	2.77	
Pineapple	90	37	63.9	3.01	
Pushmataha†	87	40	63.5	3.06	
Rockmills†	81	32	59.4	6.50	
Scottsboro†	87	32	58.0	4.09	
Selma†	88	41	64.0	4.03	
Sturdevant†				1.96	
Talladega *1	84	40	60.8	3.01	
Tallassee†				5.03	
Thomasville	87	42	64.6	1.98	
Tuscaloosa†	86	40	63.4	4.07	
Tuscumbia	84	36	60.9	4.42	
Union†	88	36	62.2	4.82	
Union Springs†	88	39	63.4	3.97	
Uniontown†	87	42	64.3	3.21	
Valleyhead	83	31	59.2	3.54	
Warrior†				2.43	
Wetumpka	89	37	63.4	5.46	
Wilsonville†				4.25	
Alaska.					
Killisnoo	48	29	39.8	4.35	
Arizona.					
Arizona Canal Co. Dam	98	36	69.0	T.	
Benson *3	87	43	68.7	0.00	
Bisbee†	82	37	63.0	0.00	
Buckeye†	100	33	68.7	0.00	
Calabasas	89	30	63.0	0.00	
Casa Grande *3	95	47	71.7	0.00	
Cedar Springs				0.00	
Congress	88	42	67.1	0.29	
Dragoon				0.00	
Dragoon Summit *3	80	35	65.4	0.00	
Dudleyville	97	37	64.0	0.35	
Farleys Camp†	95	40	67.4	0.00	
Flagstaff †	70	20	45.4		2.0
Fort Apache	82	23	52.3	0.34	
Fort Grant†	87	31	61.2	0.00	
Fort Huachuca†	85	34	60.5	0.00	
Fort Mohave	110	37	72.2	0.10	
Gilabend *a* *3	102	47	74.6	0.00	
Gisela†	90	27	59.6	T.	
Glendale	94	32	64.6	0.00	
Holbrook†	86	20	52.8	0.16	
Lochiel *1	84[f]	35[e]	60.2[e]	0.00	
Maricopa *3	102	54	77.7	0.00	
Mesa†	97	38	66.6	T.	
Mount Huachuca	87	30	61.2	T.	
Music Mountain	92	34	62.0	0.25	
Natural Bridge				0.12	
Oracle†	88	34	62.2	0.01	
Oro				0.36	
Oro Blanco	90	32	63.4	0.00	
Pantano *3	89	38	68.1	0.00	
Parker	106	37	71.3	0.07	
Payson				0.14	
Peoria†	92[e]	36	65.8[e]	0.00	
Phœnix	96	33	66.6	0.00	
Pinal Ranch				T.	
Reymert†	100	41	71.2	0.01	
Arizona—Cont'd.					
St. Helena Ranch				0.00	
San Carlos†	96	30	63.2	0.00	
San Simon *3	89	30	67.4	0.00	
Showlow				0.12	T.
Signal†	95	35	66.2	0.20	
Sulphur Spring Valley†				0.00	
Texas Hill *3	104	48	75.6	0.00	
Tombstone	89	33	63.8	T.	
Tuba	84	26	53.6	0.09	
Tucson *c*†	94	30	65.2	T.	
Walnut Grove				1.00	
Walnut Ranch *†1	78	28	58.7	0.00	
Whipple Barracks†	87	17	52.4	0.37	
Willcox *3	87	45	66.1	0.00	
Williams	78	22	48.0	0.75	6.0
Arkansas.					
Amity	82	36	61.6	2.76	
Arkansas City†				4.83	
Batesville	86	38	61.4	2.99	
Beebranch†	84[e]	35[e]	60.4[e]	3.81	
Blanchard Springs†	84	37	63.3	4.28	
Brinkley	85	38	61.6	5.91	
Camden *a*†				4.36	
Camden *b*†	84	34	62.6	4.38	
Canton *1	84	36	57.9		
Conway	88	34	63.9	3.35	
Corning†	85[e]	35[e]	58.6[e]	4.14	
Dallas	85[f]	38[d]	62.2[e]	3.39	
Dardanelle				4.36	
Elon†	85	34	62.8	2.27	
Fayetteville†	85	33	58.4	4.60	
Forrest	85	37	61.1	5.49	
Fulton†				1.89	
Helena *a*†				5.57	
Helena *b*	89	39	61.3	5.63	
Hot Springs *a*	86	38	63.0	5.03	
Hot Springs *b*				4.00	
Hot Springs (near)				5.62	
Jonesboro	87	37	61.7	3.78	
Keesees Ferry†	86	31	59.6	5.31	
Lacrosse†	86	34	57.2	2.96	
Lonoke *1	87	41	62.7	4.50	
Luna Landing *3	79	45	63.5	2.22	
Lutherville *1	86	36	62.3		
Malvern†	86	36	61.1	4.37	
Marianna *1	87	46	63.6		
Marvell	87	40	63.7	4.80	
Moore				3.77	
Mossville	80	37	57.5	5.47	
Mount Nebo†	81	39	59.4	6.12	
New Gascony *1	80	44	62.7	5.22	
Newport *a*†				4.68	
Newport *b*†	86	39	59.9	4.77	
Newport *c*†	86	37	61.1	4.76	
Oregon *1	80	32	54.2		
Osceola†	80	41	60.6	4.45	
Ozark†	85	40	63.4	3.56	
Picayune†	83	39	63.4	2.50	
Pinebluff†	87	43	65.2	4.16	
Pocahontas†	80	36	58.2	3.18	
Prescott	86	40	64.2	3.18	
Rison[f]	85	38	63.2	2.50	
Russellville	85	37	61.0	3.72	
Silver Springs †	83	27	56.4	5.82	
Stuttgart†	90	40	62.6	4.68	
Texarkana†	88	40	64.0	4.71	
Warren †	85	39	63.0	5.53	
Washington *†1	82	39	62.5	3.02	
Wiggs *1	84	38	64.2	3.80	
Witts Springs†	82	33	58.0	2.76	T.
California.					
Adin	84	26	48.6	1.27	2.5
Agnew	84	36	58.6	0.20	
Arlington Heights	93	36	63.2	0.01	
Athlone *3	93	39	61.3	0.07	
Azusa				0.15	
Ballast Point L. H				0.00	
Barstow†	94	45	75.0	0.00	
Bear Valley†				3.35	16.0
Berkeley	84	41	57.7	0.44	
Bishop†	83	26	54.4	0.00	
Bishop Creek *3	90	38	63.1	T.	
Boca *3	78	17	40.9	0.10	1.0
Bodie†	60	11	35.0	T.	
Bowmans Dam *†1	71	23	43.8	2.85	15.0
Caliente *3	85	45	63.5	0.35	
Calloway Canal†	94[d]	36[e]	62.2[e]	0.00	
Campbell	84	34	56.7	0.21	
Cape Mendocino L. H				1.50	
Castle Pinckney *1	82	50	59.8	0.03	
Cedarville†	78	23	48.7	0.56	1.0
Centerville *1	92	50	62.4	0.45	
Chico *3	92	41	65.2	1.86	
Chino *†3	95	40	62.5	0.00	
Cisco *3	50	19	36.1		7.0
Claremont†	86	33	58.0	T.	
California—Cont'd.					
Corning *3	92	35	60.7	1.63	
Coronado	97	50	65.0	0.02	
Craftonville	91	33	60.1	0.07	
Crescent City†	82	33	50.9	2.95	
Crescent City L. H				3.48	
Daunt				0.40	
Davisville *b*	94	41	67.1	0.46	
Delano *3	92	43	62.4	0.18	
Delta *3	90	31	58.2	1.30	
Descanso *3	84	25	52.3	0.16	
Drytown	90	33	59.6	0.53	
Dunnigan *3	88	44	68.3	0.42	
Durham *1	81	34	58.2	0.68	
East Brother L. H				0.05	
Edmanton *1	76	22	46.6	1.59	10.0
Elsinore	98	36	65.8	0.00	
Escondido	93	29	59.4		
Fallbrook *1	92	42	59.8	0.06	
Famosa†	84	39	57.8	0.08	
Folsom City *b* *1	91	45	63.5	0.74	
Fordyce Dam †				2.78	18.0
Fort Bragg†				1.28	
Fort Ross	79	40	53.4	0.78	
Fort Tejon				0.95	
Georgetown†	81	29	56.4	2.40	T.
Glendora				0.00	
Goshen *3	93	33	62.1	0.00	
Grand Island *3	90	38	64.7	T.	
Grass Valley				2.56	
Greenville†	85	21	49.6	0.94	3.0
Guinda				0.00	
Healdsburg *1	86	40	58.0	0.11	
Hollister	87	34	57.4	0.51	
Hueneme				0.05	
Humboldt L. H				2.23	
Hydesville	88	28	53.4	2.39	
Indio *3	102	43	72.7	0.00	
Iowa Hill *1	84	35	56.6	2.15	0.5
Jackson	84	32	55.9	1.46	
Jolon				0.00	
Keeler *3	92	41	66.9	0.00	
Keene *3	86	36	57.7	0.14	
Kennedy Gold Mine	88	34	58.8	1.51	
Kernville				0.10	
King City *3	88	42	59.5	0.11	
Kingsburg *3	90	38	64.6	0.30	
Kono Tayee	83	38	58.7	0.90	
Lagrange *3	94	40	64.4	T.	
Laporte *†1	67	27	43.7	3.12	18.0
Las Fuentes Ranch				0.00	
Lemoore *3	90	40	66.2	0.03	
Lick Observatory	73	28	51.0	0.82	0.5
Lime Kiln	100	32	65.4		
Lime Point L. H				0.18	
Lodi	86	38	60.6	0.40	
Los Alamos†				0.00	
Los Gatos *b*	88	38	58.2	0.40	
Lytton Springs	87	40	60.2	0.26	
McMullin *1	96	42	60.1		
Malakoff Mine *1	84	31	56.2	3.70	3.0
Mammoth Tank *3	107	52	79.1	0.00	
Manzana	84	30	55.2	0.04	
Mare Island L. H				0.47	
Marysville	91	39	63.0	1.53	
Merced *3	90	43	64.3	0.41	
Middletown *†1	87	31	57.6	0.00	
Mills College				0.47	
Milton (near) *1	90	38	61.4	0.47	
Modesto *3	90	44	65.2	0.00	
Mohave *3	90	42	62.1	0.00	
Mokelumne Hill *3		37	58.0	0.48	
Monterey *3	78	42	56.5	0.40	
Morena Dam *4	82	32	48.7	1.13	
Mount Breckenridge				0.00	
Mount Frazier				0.15	
Mount Glenwood *1	89	44	63.7	0.02	
Mutah Flat†				0.00	
Napa	87	33	57.8	0.33	
Needles	97	50	74.2	0.00	
Nevada City†	81	30	53.8	2.08	
Newcastle *a*†	83	35	58.6	0.48	
Newhall *3	94	40	62.8	0.00	
Nordhoff †	92	30	59.9	0.00	
North Ontario	88	38	61.4	T.	
North San Juan *1	86	34	57.7	2.20	
Oakland *a*	85	40	58.8	0.52	
Ogilby *3	105	60	83.0	0.00	
Oleta *1	83	38	56.2	1.50	
Orangevale†	91	39	62.8	0.75	
Orland *3	97	39	65.8	1.79	
Oroville *b*	92	48	68.5	0.35	
Otay Dam *1	91	48	63.5	0.00	
Palermo†	92	38	62.7	0.76	
Paso Robles *b*	83	40	58.8	T.	
Peachland *1	85	38	57.4	0.12	
Picacho	100	47	73.3	T.	

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
California—Cont'd.	°	°	°	*Ins.*	*Ins.*
Piedras Blancas L. H.	.....	.....	.....	0.50	
Pigeon Point L. H.	.....	.....	.....	0.10	
Pilot Creek	.....	.....	.....	2.60	10.0
Point Ano Nuevo L. H.	.....	.....	.....	0.30	
Point Arena L. H.	.....	.....	.....	1.11	
Point Bonita L. H.	.....	.....	.....	0.30	
Point Conception L. H.	.....	.....	.....	0.00	
Point Fermin L. H.	.....	.....	.....	0.00	
Point George L. H.	.....	.....	.....	0.61	
Point Hueneme L. H.	.....	.....	.....	0.00	
Point Lobos	80	42	53.8	0.12	
Point Loma L. H.	.....	.....	.....	0.00	
Point Montara L. H.	.....	.....	.....	0.00	
Point Pinos L. H.	.....	.....	.....	0.80	
Point Reyes L. H.	.....	.....	.....	0.47	
Point Sur L. H.	.....	.....	.....	0.10	
Pomona (near)	92	30	62.6	T.	
Poway *[3]	88	42	55.0	0.00	
Quincy †	80	27	50.0	0.99	T.
Ravenna *[3]	98	38	62.8	0.00	
Redding *b* †	89	35	62.4	3.02	
Represa	84	38	60.6	0.71	
Riovista	88	40	61.2	0.21	
Roe Island L. H.	.....	.....	.....	0.00	
Rosewood	90	29	58.4	0.42	
Sacramento *a*	87	39	62.8	0.12	
Salinas *[3]	82	40	58.7	0.35	
Salton *[3]	112	62	79.1	0.00	
San Bernardino †	92	34	61.8	0.08	
San Jose *b*	84	34	57.2	0.91	
San Leandro *[1]	89	45	60.8	0.50	
San Louis L. H.	.....	.....	.....	0.19	
San Mateo *[4]	82	50	62.7	0.06	
San Miguel *[3]	89	41	62.8	0.13	
Santa Ana *[5]	78	48	67.4	0.00	
Santa Barbara *a*	86	41	59.6	0.02	
Santa Barbara L. H.	.....	.....	.....	0.03	
Santa Clara *a*	.....	.....	.....	0.15	
Santa Cruz *b* †	90	36	59.4	0.22	
Santa Cruz L. H.	.....	.....	.....	0.30	
Santa Maria	92	37	61.0	0.14	
Santa Monica *[3]	81	49	64.4	0.00	
Santa Paula *b* †	89	33	58.5	0.00	
Santa Rosa *[3]	86	37	58.5	1.03	
Saticoy	.....	.....	.....	T.	
Shasta	.....	.....	.....	0.78	
Sierra Madre	86	39	62.0	0.10	
Sneddens Ranch *† [1]	80	12	42.0	0.02	
S. E. Farallone L. H.	.....	.....	.....	0.00	
Stanford University	83	39	57.1	0.16	
Stockton *a*	85	39	60.7	0.37	
Summerdale †	69	27	46.4	1.13	5.0
Susanville †	82	28	52.5	0.30	T.
Sutter Creek *[5]	83	28	53.8	T.	
Tecarte Dam *[4]	92	28	51.0	0.31	
Tehama *[3]	89	42	65.3	1.11	
Templeton *[3]	92	42	60.5	0.09	
Trinidad L. H.	.....	.....	.....	2.26	
Truckee *[3]	70	30	40.3	0.30	3.0
Tulare *b*	.....	.....	.....	0.40	
Tulare *c*	100	34	67.3	0.35	
Turlock *b* †	92	35	60.2	0.06	
Ukiah †	88	33	57.4	0.91	
Upper Lake	88	33	58.9	0.42	
Upper Mattole *[1]	92	35	55.2	1.83	
Vacaville *a* *[1]	90	44	62.8	0.24	
Ventura †	93	33	56.0	0.05	
Volcano Springs *[3]	112	57	81.1	0.00	
Walnutcreek	87	38	61.4	0.19	
West Palmdale	.....	.....	.....	0.04	
Westpoint †	.....	.....	.....	1.11	
Wheatland †	86	38	60.6	0.92	
Williams *[3]	90	40	64.8	0.25	
Wilmington *[5]	87	49	65.5	0.00	
Wire Bridge *[5]	89	38	62.6	1.60	
Yerba Buena L. H.	.....	.....	.....	0.00	
Yreka †	85	25	52.2	0.39	
Yuba City *[5]	89	44	72.4	1.00	
Engineers Quarters ‡	.....	.....	.....	0.03	
Morses House ‡	.....	.....	.....	0.15	
Deep Creek ‡	.....	.....	.....	0.00	
Holcomb Creek ‡	.....	.....	.....	0.00	
Squirrel Inn ‡	.....	.....	.....	0.13	
Colorado.					
Alma †	56	1	29.2	1.14	13.0
Antlers †	78	12	46.6	0.97	4.0
Arkins	.....	.....	.....	1.82	3.5
Boxelder	.....	.....	.....	1.22	8.0
Breckenridge †	67	— 8	30.0	4.00	40.0
Canyon †	79	21	50.6	0.75	T.
Castlerock †	63	0	41.4	1.37	8.0
Cheyenne Wells	82	26	55.0	1.05	T.
Colibran	.....	.....	.....	1.04	0.5
Colorado Springs †	73	18	44.2	0.54	0.6
Cripple Creek †	60	1	32.1	1.21	12.0
Delta	86	19	51.7	0.05	0.0
Colorado—Cont'd.					
Downing †	80	15	48.2	0.96	1.0
Dumont †	70	13	40.1	1.43	7.0
Durango	73	21	46.7	0.45	1.0
Fleming	.....	.....	.....	2.20	12.0
Fort Collins †	77	20	45.8	1.39	3.8
Fort Morgan [2]	.....	23	45.0	0.06	0.0
Fox	.....	.....	.....	0.94	4.0
Garnett	82	12	41.6	0.10	T.
Gleneyrie †	70	19	43.4	0.44	.....
Gold Hill *[1]	71	14	42.0	2.93	16.8
Grand Junction †	80	24	52.3	1.12	1.5
Greeley †	82	19	47.5	0.81	
Gulch †	74	15	39.6	2.20	18.0
Gunnison †	73	5	39.8	.....	.....
Holly	.....	.....	.....	1.17	T.
Holyoke *a*	.....	.....	.....	2.36	8.0
Hugo (near)	78	12	43.4	0.49	4.8
Husted †	76	10	44.8	1.60	3.2
Lake Moraine †	56	— 1	29.5	1.75	17.5
Lamar †	87	23	52.5	0.45	.....
Laporte	.....	.....	.....	1.62	9.0
Las Animas †	83	23	50.9	0.85	0.0
Lay †	72	— 1	39.6	1.83	9.5
Leadville (near) *† [1]	63	7	32.0	1.50	15.1
Ler·y †	84	21	45.8	1.77	9.0
Longmont †	84	23	49.8	.....	.....
Longs Peak	60	1	32.5	1.45	17.5
Loveland	.....	.....	.....	0.94	.....
Meeker †	76	9	42.4	2.19	5.6
Millbrook †	77	11	42.8	1.27	6.0
Minneapolis †	85	17	51.7	1.27	.....
Montrose †	80	18	47.5	0.97	3.0
Moraine †	65	4	36.6	1.29	12.5
Pagoda †	70	—11	38.6	3.50	30.5
Paonia †	.....	.....	.....	0.20	0.0
Parachute †	79	10	48.6	3.98	.....
Pinkhamton *[1]	81	2	40.1	1.95	19.5
Rangely †	81	23	48.0	0.05	0.0
Redcliff	.....	.....	.....	0.77	7.7
Rico †	64	3	35.9	1.66	13.0
Rockyford †	85	20	50.2	0.44	0.0
Ruby	.....	.....	.....	10.50	105.0
Saguache †	71	18	44.4	T.	T.
St. Cloud	.....	.....	.....	2.12	17.0
San Luis †	80	10	43.0	0.51	1.2
Santa Clara *[1]	65	12	40.8	3.85	19.0
Seibert †	.....	.....	.....	2.57	13.0
Smoky Hill Mine †	70	6	38.0	2.81	23.0
Stamford *[1]	60	4	31.8	2.60	26.0
Sulphur Springs †	73	— 3	40.4	2.40	19.0
Surface Creek †	77	15	46.5	1.23	1.5
Thon †	78	9	43.3	1.65	2.0
T. S. Ranch †	77	16	47.4	1.15	4.0
Twin Lakes	.....	.....	.....	1.09	10.0
Vilas	.....	.....	.....	2.19	.....
Walden	68	2	33.8	0.90	7.0
Wallet †	.....	.....	.....	1.70	3.0
Wray †	86	20	49.2	1.64	5.0
Yuma	.....	.....	.....	0.80	4.0
Connecticut.					
Bridgeport	73	25	48.4	2.53	
Canton †	80	17	47.2	2.55	T.
Colchester	80	23	48.3	2.77	T.
Hartford *b*	.....	.....	.....	2.49	T.
Middletown	78	22	49.1	2.65	T.
New London †	73	24	46.0	3.69	T.
Norwalk	76	21	47.8	2.41	
Southington *[1]	77	24	47.6	2.03	
Storrs	78	19	45.9	2.37	T.
Voluntown †	77	23	47.4	3.66	T.
Waterbury	77	22	49.0	1.97	T.
West Cornwall †	76	16	45.0	3.16	.....
Windsor	77	22	47.8	2.28	T.
Delaware.					
Milford	89	30	54.4	2.69	
Millsboro	86	27	52.5	3.20	
Newark	85	26	50.5	2.87	
Seaford †	86	29	53.6	3.98	
District of Columbia.					
Distributing Reservoir *[5]	85	30	54.8	2.60	
Receiving Reservoir *[5]	84	31	54.0	2.77	
West Washington	88	27	53.0	3.08	
Florida.					
Amelia †	81	47	67.0	4.16	
Archer †	92	40	70.2	5.24	
Bartow	89	47	71.2	4.07	
Boca Raton †	85	55	73.3	6.95	
Brooksville †	89	45	71.0	1.90	
Clermont †	94	48	72.0	2.01	
De Funiak Springs	88	38	64.9	4.50	
Earnestville †	94	43	71.3	3.68	
Emerson †	94	36	68.8	4.37	
Eustis †	89	40	70.7*	1.52	
Federal Point †	87	45	67.4	5.13	
Fort Meade † [1]	88*	44	69.0	3.57	
Frostproof †	91	52	72.0	2.17	
Florida—Cont'd.					
Gainesville	90	42	69.2	4.89	
Grasmere †	90	47	71.2	1.58	
Haywood	90	37	66.7	6.99	
Huntington	91	46	70.6	4.82	
Kissimmee	.....	48	.....	2.75	
Lake Butler †	90	52	71.2	7.04	
Lake City †	93	42	71.9	5.00	
Lemon City †	89	58[6]	74.2[7]	10.55	
Macclenny †	92	42	68.4	4.51	
Manatee †	90	49	69.8	4.13	
Merritts Island †	86	52	72.4	3.18	
Milton *[1]	82	42	65.0	8.25	
Mullet Key †	82	54	71.7	2.39	
Myers †	90	53	72.5	7.26	
Oakhill *[1]	84	51	72.0	.....	
Ocala *† [1]	88	44	69.8	3.96	
Orange City	91	49	71.8	1.47	
Orange Park	89	40	69.8	3.74	
Orlando †	87	46	68.4	2.83	
Oxford *† [1]	92	55	71.9	2.34	
Plant City †	91	46	71.4	4.14	
Quincy	86[4]	53[4]	70.9[4]	7.66	
St. Francis †	90	39	68.3	2.09	
St. Francis Barracks	82	45	67.0	6.65	
Tallahassee †	84	40	65.4	9.29	
Tarpon Springs †	88	45	69.8	2.22	
Georgia.					
Adairsville † [6]	83	33	58.0	4.27	
Albany †	91	41	65.0	3.69	
Allentown †	93	37	64.2	4.16	
Americus †	94	35	65.4	3.00	
Belleville [4]	95	45	68.0	4.80	
Blakely †	88	38	65.8	3.57	
Brag †	91	37	65.8	2.20	
Canton †	.....	.....	.....	4.59	
Cartersville	85	33	58.6	3.83	
Cedartown	86	33	60.2	3.34	
Clayton †	85	32	56.2	11.65	
Columbus	90	35	63.6	5.09	
Covington	86	31	57.6	4.29	
Dahlonega †	86	31	57.6	7.10	
Diamond	88	27	55.3	5.44	
Dublin	.....	.....	.....	3.92	
Elberton †	88	37	61.3	5.02	
Fleming †	90	38	64.0	3.78	
Gillsville †	86	39	60.3	6.62	
Greenbush	85	31	58.1	.....	
Hawkinsville	87	28	62.6	3.60	
Hephzibah *† [6]	84	44	64.9	3.50	
Jesup	91	43	67.1	4.71	
Lagrange †	86	36	63.1	6.09	
Leverett	91	36	61.6	3.46	
Louisville †	88	37	63.0	3.39	
Lumpkin	89	38	65.5	4.77	
Macon † *b*	.....	.....	.....	3.30	
Marietta	83	34	58.2	4.35	
Marshallville †	87	40	64.6	5.57	
Milledgeville †	88	40	64.0	2.53	
Monticello *† [1]	82	40	63.4	4.55	
Morgan †	89	34	62.2	4.09	
Newnan †	89	38	60.9	4.83	
Piscola	89	41	67.7	6.50	
Point Peter	86	36	58.6	6.51	
Poulan †	89	34	64.0	2.68	
Quitman †	89	37	66.2	5.16	
Ramsey	86	33	59.7	6.13	
Resaca †	.....	.....	.....	5.25	
Reynolds	.....	.....	.....	4.25	
Rome †	85	33	59.3	3.16	
Sparta	89	36	62.2	3.75	
Talbotton †	85	36	60.6	3.38	
Tallapoosa	84	34	58.4	3.28	
Thomasville †	90	39	66.1	4.98	
Toccoa †	87	38	60.1	7.19	
Washington †	.....	.....	.....	3.28	
Whitesburg	.....	.....	.....	3.96	
Idaho.					
Blackfoot †	78	24	45.6	1.40	1.1
Boise Barracks †	86	29	49.9	1.10	T.
Burnside †	70	15	38.3	0.02	0.2
Cœur d'Alene	79	28	47.0	.....	.....
Corral *† [1]	71	16	37.6	0.88	.....
Downey	72	18	42.6	1.20	4.5
Fort Sherman †	87	27	47.5	1.65	T.
Gimlet †	77	10	41.4	0.96	5.0
Idaho City	80[6]	9[6]	40.6[6]	1.41	7.4
Kootenai †	84	24	50.6	0.58	
Lake †	50	6	30.0	0.00	
Lewiston *a* †	90	32	55.0	1.38	
Lost River †	.....	.....	.....	0.13	1.0
Martin †	66	9	37.8	0.40	4.0
Marysville	64	12	41.4	1.51	8.1
Minidoka †	80	16	47.8	0.30	3.0
Murray †	75	23	44.8	2.40	3.0
Nampa	87	27	50.4	0.96	
Oakley	83	13	47.6	0.92	.....

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Idaho—Cont'd.	°	°	°	*Ins.*	*Ins.*
Ola †	88	23	47.0	1.35	
Paris	72	8	37.8	0.79	.....
Payette †	90	28	53.0	0.74	
Pollock †	87	29	53.4	0.41	
Rexburg	.....	.....	.....	0.10	
Roseberry †	58	15	34.6	0.50	0.2
St. Maries *	80	30	48.8	1.16	
Soldier †	70	11	37.1	0.75	5.0
Swan Valley †	63	12	36.9	1.68	12.2
Warren †	80	12	40.9	1.47	.....
Illinois.					
Albion †	85	28	54.4	7.47	
Alexander †	79	28	52.4	4.35	
Ashton *† [1]	78	27	47.2	3.19	2.0
Atlanta *[5]	78	27	51.4	4.33	0.1
Atwood *† [2]	76	30	47.6	8.08	T.
Atwood *b*	.....	.....	.....	5.12	
Aurora *a*	84	18	48.8	3.04	.....
Aurora *b*	78	19	47.2	2.88	0.6
Beardstown †	.....	.....	.....	5.26	
Bloomington †	82	23	49.2	3.92	1.0
Bushnell †	84	28	50.5	3.90	
Cambridge	78	26	48.2	3.70	0.5
Carlinville †	79	30	53.4	5.85	
Carlyle	.....	.....	.....	4.45	
Carrollton	77	29	50.6	4.33	
Charleston	79	25	50.8	6.41	T.
Chemung *[1]	76	20	45.0	4.66	
Chester	.....	.....	.....	6.28	
Cisne †	82	29	54.1	5.51	
Clearcreek †	82	21	48.0	2.36	2.0
Coatsburg †	80	29	52.6	4.09	
Cobden †	81	34	55.7	8.31	
Cordova	.....	.....	.....	3.63	
Decatur †	80	25	51.4	3.87	T.
Dixon †	80	22	48.1	3.43	6.0
Duquoin *[1]	86	35	55.0	5.69	
Dwight †	82	18	48.4	2.74	0.5
East Peoria †	81	24	50.4	3.19	
Effingham †	81	27	53.2	5.68	T.
Fort Sheridan †	76	23	45.1	2.20	.....
Friendgrove *†	.....	30	52.8	8.00	
Galva †	81	24	48.6	2.61	T.
Glenwood *† [1]	80[4]	26[4]	46.6[4]	1.93	
Golconda †	82	33	56.5	7.65	
Grafton †	.....	.....	.....	6.51	
Greenville †	82	30	53.6	3.90	
Griggsville †	80	30	52.4	4.25	
Halliday *[5]	80[4]	34[4]	57.4[4]	5.15	
Havana †	78	32	52.0	3.74	T.
Herrin *[1]	78	38	56.6	6.34	
Hillsboro †	79	29	53.2	4.07	T.
Iron †	82	31	56.0	6.88	
Joliet †	81	21	50.3	2.87	0.4
Jordans Grove †	80	35	55.2	3.35	T.
Kankakee *a* †	77	23	48.0	1.99	
Kishwaukee	77	22	46.2	2.91	2.0
Knoxville *a* *[5]	79	26	48.3	4.18	T.
Lagrange †	80	20	47.2	3.50	0.5
Laharpe *[1]	74	30	50.4	5.85	
Lanark *† [1]	76	24	46.6	2.67	1.0
Lexington	80	22	50.4	2.70	
Loami †	.....	.....	.....	4.27	
Louisville †	79	28	53.6	6.00	T.
McLeansboro †	81	30	54.3	7.27	
Martinsville †	80	25	52.2	5.72	0.5
Martinton †	83	20	49.0	2.26	
Mascoutah *[5]	80	34	55.2	8.64	
Mattoon *[1]	78	27	51.9	6.38	
Minonk †	78	21	49.2	2.93	2.0
Monmouth †	80	27	49.6	3.25	.....
Morgan Park	74	20	45.3	.....	.....
Morrisonville †	78	28	51.4	5.27	
Mount Carmel †	.....	.....	.....	6.20	T.
Mount Pulaski	76	26	51.0	2.98	0.5
Mount Vernon	81	20	53.0	4.47	
New Burnside †	83	34	57.1	5.82	
Olney *a* [1]	82	26	55.2	6.49	T.
Oregon †	76	20	47.0	2.40	.....
Oswego *[1]	76	20	46.0	2.36	T.
Ottawa †	81	20	48.8	1.88	2.2
Palestine †	84	26	53.0	5.60	1.0
Paris	.....	22	.....	4.63	.....
Peoria *a* †	.....	.....	.....	3.50	.....
Peoria *b* †	81	28	50.4	2.87	0.5
Philo †	80	20	49.4	3.48	
Plumhill †	80	32	54.4	5.13	
Rantoul †	82	22	49.2	3.54	T.
Reynolds	79	27	48.7	3.84	T.
Riley †	76	21	45.6	2.59	0.4
Robinson *† [3]	82	30	51.6	6.41	
Rockford †	81	26	47.2	3.91	1.1
Rose Hill *† [1]	84	33	54.7	6.30	
Roundgrove †	82	22	49.2	2.88	.....
St. Charles *† [1]	80	28	46.3	3.47	T.
St. John *† [1]	81	34	54.6	4.55	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Illinois—Cont'd.	°	°	°	*Ins.*	*Ins.*
Scales Mound	74	22	46.4	3.57	4.0
Streator †	80	23	48.8	1.88	2.3
Sycamore †	77	22	45.4	3.78	T.
Tiskilwa *† [3]	.....	24	45.8	2.77	1.0
Tuscola †	81	23	50.6	4.76	0.1
Warsaw †	.....	.....	.....	1.20	
Walnut †	.....	24	.....	3.71	3.2
Wheaton *[3]	.....	27	45.2	4.36	3.8
Winnebago †	76	23	46.6	3.63	2.0
Zion †	75	20	46.1	3.16	3.0
Indiana.					
Anderson †	80	21	50.2	4.70	3.0
Angola *[1]	80	15	46.6	2.90	2.4
Bloomington †	82	23	52.0	6.02	T.
Bluffton †	83	21	47.6	4.25	8.0
Bright †	80	23	51.7	4.54	0.5
Butlerville †	83	23	53.0	4.63	1.0
Cambridge City †	81	21	49.0	5.45	2.0
Columbia City *[1]	76	20	47.0	3.20	2.5
Columbus †	83	22	51.7	5.25	0.2
Connersville †	80	21	49.3	4.99	1.0
Delphi †	83	18	48.9	2.89	T.
Edwardsville *† [1]	82	27	55.0	4.12	
Evansville †	86	29	54.4	5.89	
Farmland †	79	21	48.4	4.47	8.0
Fort Wayne	80	20	48.0	3.87	2.0
Greencastle †	79	23	50.4	3.64	3.7
Greensburg	80	29	54.8	5.97	
Hammond †	73	26	46.5	0.99	2.0
Huntingburg	78	29	51.2	8.00	
Huntington	80	19	47.6	3.45	5.5
Jasper †	84	27	55.6	5.35	T.
Jeffersonville	85	28	55.5	4.11	
Knightstown †	82	22	50.4	6.02	3.0
Knox	87	18	49.9	1.90	
Kokomo †	84	21	50.5	3.76	1.0
Lafayette †	81	20	49.0	2.86	T.
Laporte	78	.....	.....	2.35	.....
Logansport *b* †	81	21	47.4	2.84	
Madison †	84	26	54.2	4.12	T.
Marengo †	87	27	55.6	5.08	T.
Marion †	81	19	49.1	3.90	2.0
Mauzy †	80	21	50.0	5.15	2.5
Mount Vernon †	.....	.....	.....	6.74	
Northfield †	79	20	48.8	4.57	4.0
Princeton *[1]	84	28	54.0	5.98	0.2
Richmond	81	22	50.7	4.83	0.5
Rockville †	82	22	50.9	3.97	
Rushville †	.....	.....	.....	5.57	1.5
Salem	90	22	53.8	3.65	
Scottsburg	85	27	56.3	4.42	T.
Seymour †	82	24	51.5	3.44	
Shelbyville	82	25	51.4	5.47	T.
South Bend †	80	15	47.2	2.52	1.5
Syracuse †	.....	.....	.....	2.28	0.2
Terre Haute †	80	24	52.6	4.53	
Tipton †	84	20	51.3	3.95	2.0
Topeka †	79	23	47.6	2.13	T.
Valparaiso †	80	18	47.6	2.50	
Vevay	88	28	54.0	5.80	
Vincennes †	86	28	55.6	6.93	
Warsaw †	80	19	49.2	2.52	T.
Washington †	84	21	54.8	5.73	0.1
Worthington †	82	25	53.8	5.85	T.
Indian Territory.					
Afton	86	37	58.8	2.84	
Eufaula	.....	.....	.....	7.01	
Healdton †	87	37	63.0	2.55	
Kemp †	83	39	63.4	3.26	
Lehigh †	82	37	60.8	4.83	
Purcell	94	.....	.....	3.06	
South McAlester	85	35	62.3	7.75	
Tahlequah	84	31	60.2	6.60	
Tulsa †	.....	.....	.....	5.60	
Iowa.					
Adair	.....	.....	.....	7.28	
Afton	80	26	49.0	8.01	
Algona *[1]	78	24	46.8	3.50	2.0
Alta *a* †	78	30	45.6	4.23	
Amana †	77	27	48.0	7.17	
Ames *b*	81	26	48.2	5.70	
Ames (near)	80	26	47.8	5.82	
Atlantic †	79	25	48.1	6.80	
Atlantic (near)	78	25	49.8	5.52	
Audubon	77	23	46.2	5.27	
Belknap	80	28	50.3	3.89	
Belleplaine	75	26	46.0	7.69	
Bonaparte †	82	28	50.2	2.41	
Britt	76	21	44.6	3.63	T.
Carroll	78	22	46.6	6.81	
Cedarfalls	78	25	47.8	5.59	
Cedar Rapids †	80	26	47.4	5.97	
Centerville	80	28	50.6	8.37	
Chariton	77	28	50.2	8.48	
Charles City †	76	23	46.1	3.82	T.
Clarinda †	82	29	50.8	6.00	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Iowa—Cont'd.	°	°	°	*Ins.*	*Ins.*
Clinton	82	24	49.7	2.36	3.0
College Springs	84	26	51.2	5.29	
Corning †	79	25	48.9	7.88	
Council Bluffs	80	28	50.3	5.40	
Cresco †	74	22	44.8	2.23	T.
Decorah †	78	21	46.2	3.76	
Delaware *[3]	73	24	45.2	4.89	
Denison †	78	22	47.6	5.88	
Dows	77	23	46.4	4.69	
Eldora	81	23	45.8	5.87	
Elkader †	79	20	46.1	4.05	
Fairfield †	76	28	48.3	4.11	
Fayette †	78	20	45.8	3.00	
Fonda	.....	.....	27	.....	6.09
Forest City	76	22	44.8	4.16	
Fort Madison *† [1]	80	35	52.9	4.13	
Fredericksburg	.....	.....	.....	3.01	
Galva †	78[c]	24[4]	48.2[c]	3.79	
Gardengrove	80	24	48.2	6.95	
Gladbrook	.....	.....	.....	7.32	
Glenwood †	80	21	46.5	5.65	
Grand Meadow *[1]	73	22	44.4	3.48	
Greene	78	24	46.5	3.62	T.
Greenfield †	81	24	49.0	5.12	
Grinnell †	76	27	48.0	7.04	
Grundy Center	79	24	45.9	5.81	1.0
Hampton	77	23	45.0	4.96	0.4
Hawkeye	.....	.....	.....	3.15	
Hopeville †	78	27	49.2	8.92	
Humboldt †	80	23	47.0	4.05	
Independence †	.....	21	.....	6.13	
Indianola †	80	26	51.2	6.10	
Iowa City *a* †	81	27	48.9	4.60	
Iowa City *b*	78	20	49.0	.....	
Iowa Falls †	77	24	46.2	4.31	T.
Keosauqua	84	29	51.5	3.66	
Knoxville	81	27	50.0	7.05	
Lansing	77	21	48.8	2.24	
Larchwood	.....	.....	.....	3.29	T.
Larrabee †	82	19	44.9	2.84	T.
Leclaire	.....	.....	.....	3.60	
Lemars	81	23	47.0	4.36	
Lenox *[1]	77	31	49.6	7.21	
Logan †	82	28	49.3	6.18	
Malvern *[1]	88	23	49.6	5.61	
Maple Valley	.....	.....	.....	3.65	
Maquoketa	78	26	49.0	3.24	2.0
Marshall †	79	26	47.7	5.98	
Millman	.....	.....	.....	7.90	
Monticello *† [1]	75	25	46.9	5.86	
Mooar	79	26	49.6	.....	
Mountayr †	86	26	50.4	7.93	
Mount Pleasant *[1]	74	32	50.8	3.59	
Mount Vernon *a* [1]	74	25	47.7	6.52	
Mount Vernon *b*	79	24	47.0	6.62	0.5
Neola	80	25	47.6	6.70	
New Hampton	74	23	46.4	2.26	
Newton †	78	26	48.8	6.09	
North McGregor	.....	.....	.....	2.84	
Northwood	75	20	44.4	2.22	
Odebolt	.....	.....	.....	6.36	
Ogden	79	26	48.1	5.24	
Osage *† [3]	.....	27	43.4	3.21	0.5
Osceola	78	28	49.6	9.74	
Oskaloosa †	84	27	49.9	5.32	
Ottumwa [1]	81	31*	50.3	5.53	
Ovid †	80	27	50.1	7.20	
Plover	79	20	47.8	3.86	
Primghar	79	20	46.3	4.78	T.
Red Oak	81	26	50.6	5.62	
Reinbeck	.....	.....	.....	4.58	
Rockwell City	81	23	47.0	3.44	
Sac City †	77	20	45.5	5.00	
St. Charles	81	26	49.1	6.45	
Seymour †	80	28	50.1	5.75	
Sibley	80	20	44.7	3.68	0.5
Sidney	76	29	50.6	5.82	
Sigourney	82	27	50.0	4.46	
Spencer	79	20	45.4	4.20	T.
Spirit Lake †	79	20	44.8	3.46	T.
Stuart	78	26	48.2	7.03	
Toledo	77	25	47.0	4.88	
Villisca †	80	27	49.6	7.79	
Vinton *[1]	76	28	47.4	6.73	
Washington	81	26	48.0	.....	
Waterloo	78	25	46.2	5.16	
Waukee	78	23	49.3	9.54	
Waverly	77	24	46.6	5.04	T.
Webster City †	76	25	47.7	3.81	
Westbend *† [1]	77	24	44.5	4.21	T.
Wilton Junction †	79	26	48.4	4.33	
Winterset †	80	25	50.4	9.86	
Kansas.					
Abilene †	89	29	54.8	3.14	
Achilles *[2]	88[4]	30	44.8[4]	4.54	T.
Altoona *† [3]	81	34	54.9	3.58	

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Kansas—Cont'd.	°	°	°	*Ins.*	*Ins.*
Anthony	.....	.....	.....	3.40	
Assaria*[5]	84	28	50.4	2.75	
Atchison†	84	33	52.6	7.17	
Augusta	86	30	55.8	2.80	
Baker	84	31	53.6	5.64	
Beloit†	86	30	54.4	3.52	
Burlington†	88	31	58.0	1.95	
Campbell	85	29	52.4	3.49	
Colby†	83	25	48.8	4.06	1.0
Columbus†	83	31	56.4	2.84	
Coolidge†	85	23	51.4	2.09	
Cunningham†	81	29	54.9	4.36	
Downs	.....	.....	.....	5.04	
Dresden*[1]	82	28	47.6	7.06	2.5
Effingham	81	32	53.5	.....	
Elgin*[1]	83	35	55.7	4.70	
Ellinwood†	89	30	53.7	3.50	T.
Emporia*†[1]	83	36	55.3	3.10	
Englewood†	91	26	56.4	3.79	
Eureka†	.....	.....	.....	2.95	
Eureka Ranch†	86	29	51.2	5.96	
Fall River	83	33	57.6	3.04	
Fort Riley†	87	32	55.5	2.08	
Fort Scott†.	84	32	55.4	3.59	
Frankfort	86	31	55.4	4.35	
Garden City†	87	24	53.3	2.09	
Garfield	.....	.....	.....	4.67	
Gibson*[5]	86	27	49.6	4.90	T.
Goodland	81	23	47.7	1.89	
Gove*†[1]	83	31	51.7	4.68	
Grainfield*[6]	82	28	50.4	3.80	
Grenola*[1]	86	32	56.0	5.77	
Halstead	82	30	51.8	3.80	
Horton	84	32	52.9	4.87	
Hutchinson†	90	34	57.0	3.19	
Independence†	87	33	57.9	3.79	
Lakin†	92	.....	.....	1.70	
Lawrence	84	32	54.2	1.96	
Lebo†	86	32	54.9	2.15	
Macksville	88	30	53.0	3.62	
McPherson	89	32	54.6	4.13	
Manhattan*b*	89	31	54.8	4.19	
Manhattan*c*	88	28	54.9	3.66	
Marion†	88	30	55.4	2.35	
Meade†	96	30	58.2	4.63	
Medicine Lodge†	91	28	56.6	3.73	
Minneapolis†	88	27	53.8	2.38	
Morantown†	82	32	55.4	3.04	
Morland	85	28	49.9	6.00	T.
Morton†	87	25	54.6	3.49	
Mounthope*[1]	84	37	54.9	3.18	
Ness City	.....	27	.....	4.97	
Newton	85	31	55.4	3.26	
Norton	84	27	50.0	4.71	T.
Norwich†	88	31	56.4	3.36	
Oberlin†	.....	.....	.....	6.70	
Olathe†	86	31	54.8	2.53	
Osage City†	85	31	54.8	2.49	
Oswego	85	33	58.0	3.33	
Ottawa	86	29	55.2	2.28	
Paola†	85	28	54.4	1.35	
Phillipsburg	86	30	52.6	4.56	
Pleasant Dale	88	30	52.4	5.42	T.
Pratt	87	30	53.6	3.30	
Rome*†[1]	84	33	55.8	4.30	
Russell	88	28	54.0	5.68	
Salina†	89	26	54.1	3.72	
Sedan†	83	32	56.4	5.15	
Seneca	82	31	52.2	4.36	
Sharon Springs*[1]	87	29	49.2	3.00	
Toronto	87	30	56.0	3.35	
Ulysses†	86[1]	25[1]	51.8[1]	1.40	
Wallace*[1]	84	26	51.1	2.09	T.
Wamego*[1]	87	32	53.6	3.20	
Wellington*[1]	82	36	56.6	4.81	
Winona*[5]	89	28	52.0	3.75	
Yates Center	85	31	55.5	4.06	
Kentucky.					
Alpha†	90	29	57.6	7.26	
Ashland	85	29	54.0	.....	
Bardstown†	87[3]	27[3]	55.2[3]	6.16	
Blandville†	80	34	56.9	7.77	
Bowling Green*a*†[1]	84	28	55.3	8.57	
Bowling Green*b*†	85	32	57.6	7.45	
Burnside†	.....	.....	.....	5.51	
Caddo†	81	26	53.4	3.73	T.
Canton*†[5]	82	35	58.8	9.97	
Carlisle	82	26	52.9	4.31	
Carrollton†	87	31	56.8	2.96	T.
Catlettsburg*†[1]	82	33	51.4	4.65	
Earlington	86	34	58.6	6.21	
Edmonton†	82	31	56.0	6.57	
Ensor	83	29	56.7	5.27	
Eubank†.	84	25	54.0	7.10	
Falmouth†	.....	.....	.....	4.26	
Fords Ferry†	86	30	56.0	5.38	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Kentucky—Cont'd.	°	°	°	*Ins.*	*Ins.*
Frankfort†	83	29	54.2	5.58	
Franklin†	80	35	56.8	6.76	
Georgetown	80	27	54.0	.....	
Greensburg†	87	27	55.6	7.16	
Henderson†	89	31	57.6	6.29	
Hopkinsville†	84	32	55.3	8.84	
Leitchfield†	86	26	54.1	5.72	
Lyndon	82	26	54.4	3.90	
Marrowbone†	85	28	56.4	7.82	
Maysville	85	28	53.8	4.17	
Middlesboro†	87	27	54.8	6.75	
Mount Sterling†	81	28	53.2	5.60	
Owensboro†	84	30	55.4	6.72	
Owenton†	84	25	53.3	7.07	T.
Paducah*a*†	.....	.....	.....	9.23	
Paducah*b*†	85	36	59.3	9.89	
Pleasure Ridge Park†	86	27	55.0	4.40	
Princeton	85	32	57.2	6.45	
Richmond†	88	27	54.5	6.77	
Russellville†	87	30	58.0	7.81	
St. John†	84	27	54.8	5.11	
Sandyhook	.....	.....	.....	4.78	
Shelbyville†	89	27	54.6	4.59	
Southfork[2]	.....	.....	55.7	5.16	
Vanceburg†	82	27	50.2	4.30	
Williamsburg†	85	29	59.0	6.48	
Louisiana.					
Abbeville	84	47	67.8	12.40	
Alexandria†	84	42	66.2	3.31	
Amite†	88	40	68.3	6.07	
Bastrop†	84	37	64.6	1.52	
Baton Rouge†	85	44	67.6	7.27	
Calhoun	83	38	64.2	2.00	
Cameron†	.....	.....	.....	2.53	
Cheneyville†	90	40	65.5	2.58	
Clinton†	84	41	65.2	2.77	
Covington	86	42	68.5	7.74	
Davis	83	34	61.0	1.93	
Donaldsonville†	90	45	69.2	11.08	
Elm Hall	85	42	64.6	7.15	
Emilie†	83	46	66.4	4.83	
Farmerville	84	39	64.2	1.98	
Franklin†	86	46	68.6	7.26	
Grand Coteau	85	47	68.6	2.46	
Hammond	85	42	65.5	6.45	
Houma	86	44	68.4	10.64	
Jeanerette	88	44	68.6	7.40	
Lafayette†	88	42	68.0	4.49	
Lake Charles†	87	45	68.0	2.83	
Lake Providence	85	41	64.8	2.00	
Lawrence	87	48	68.8	6.66	
Liberty Hill	86	36	65.0	3.44	
Mansfield†	86	37	64.8	2.81	
Melville	82	50	67.0	1.57	
Minden	88	40	64.4	1.89	
Monroe†	81	44	65.0	2.29	
Montgomery	88	37	66.4	2.46	
New Iberia	84[4]	48[4]	68.6[4]	8.74	
Oakridge†	87	38	64.6	2.67	
Oberlin	89	40	66.0	3.60	
Opelousas†	86[3]	43[3]	68.0[3]	3.17	
Oxford†	89	36	64.3	2.92	
Paincourtville†	87	44	68.5	10.28	
Plain Dealing†	81	40	64.6	4.31	
Rayne	90	41	68.2	3.76	
Robeline	86	35	63.8	2.26	
Ruston	83	42	65.1	2.84	
Schriever	89	43	68.4	8.18	
Shellbeach	84	49	69.8	4.76	
Southern University†	81	45	65.4	5.35	
Sugar Ex. Station†	82	49	67.6	5.89	
Sugartown†	84	45	68.6	1.26	
Thibodeaux	.....	.....	.....	9.60	
Venice†	82	50	67.4	4.85	
Wallace	84	48	68.0	6.41	
Whitehall	88	41	68.1	4.69	
White Sulphur Springs	84	42	67.4	2.85	
Maine.					
Bar Harbor	70	16	42.5	2.75	4.0
Belfast*[6]	62	21	43.1	2.90	6.0
Cornish*[1]	82	16	44.7	3.07	3.2
Fairfield	77	11	43.4	2.40	
Fort Fairfield	75	12	42.0	1.76	
Gardiner	75	16	45.4	2.86	1.5
Kineo†	68	8	39.0	3.27	2.0
Lewiston	76	18	44.8	2.93	
North Bridgton	77	14	43.6	2.93	3.0
Orono	74	14	42.3	3.03	
Maryland.					
Annapolis	81	29	54.9	2.80	
Bachmans Valley	85	23	49.2	3.37	
Boettcherville[2]	.....	.....	46.1	2.30	
Charlotte Hall†	90	32	54.6	2.33	
Cherryfields†[2]	.....	.....	52.9	2.73	T
Chestertown†	81	30	51.8	3.58	
Collegepark	86[7]	26[7]	51.8[7]	3.35	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Maryland—Cont'd.	°	°	°	*Ins.*	*Ins.*
Cumberland*b*	86	31	54.9	3.00	T.
Darlington†	84	27	51.0	3.16	
Deerpark	.....	17	.....	2.77	.....
Denton	87	28	53.5	2.90	
Easton†	85	30	52.3	2.36	
Ellicott City	81	30	52.8	2.46	
Fallston*[1]	79	28	50.2	3.22	T.
Flintstone	86	20	49.2	2.75	
Frederick	89	27	52.2	2.32	
Grantsville	79	18	45.7	2.99	0.2
Greatfalls*[5]	83	30	53.5	2.18	
Greenspring Furnace	87	25	51.2	2.19	
Hagerstown†	88	26	53.5	2.37	
Jewell†	87	27	53.1	2.16	
Johns Hopkins Hospital	84	27	52.2	3.35	
Laurel	87	26	51.3	3.29	
McDonogh*	85	26	53.3	.....	
Mardela Springs†	86	29	52.6	4.15	
Mount St. Marys Coll.†	86	24	50.9	2.90	
New Market	89	25	52.8	3.15	
Pocomoke City	89	32	56.8	3.29	
Port Deposit	83	28	52.5	2.66	
Princess Anne	86	25	52.7	3.24	
Sharpsburg	88	26	51.6	2.21	
Smithsburg	83	24	49.5	2.77	
Solomons†	81	31	53.9	2.00	
Sunnyside	78	15	45.4	5.06	0.4
Taneytown†	94	25	52.4	3.10	
Van Bibber	80	28	52.1	3.81	
Western Port	87	24	50.7	3.07	
Westminster	88	23	53.7	3.13	
Woodstock	86	26	50.8	2.63	
Massachusetts.					
Amherst	81	20	47.4	2.57	T.
Bluehill (summit)	78	18	46.4	3.20	1.0
Cambridge *a*	83	20	49.6	2.70	
Chestnut Hill	83	19	49.5	3.23	T.
Concord†	84	20	47.2	2.26	T.
Fallriver*[1]	73	22	45.4	3.95	T.
Fitchburg *b*	85	18	47.5	1.81	T.
Framingham	84	20	51.0	2.85	
Groton	82	17	46.4	2.04	
Hyannis*†[8]	72	26	49.1	5.57	
Lawrence	84	17	48.0	2.06	
Leeds	82	19	46.9	2.32	T.
Leicester Hill	80	17	45.8	1.93	T.
Lowell *a*	82	19	47.6	2.25	T.
Middleboro	75	20	46.1	3.80	T.
Monson	84	20	48.2	1.61	T.
New Bedford *a*	67	22	45.4	4.30	
Pittsfield	80	18	44.6	3.67	
Springfield Armory	80	14	45.2	2.34	
Taunton *b*	74	23	46.8	4.07	T.
Wakefield	82	20	48.6	2.88	T.
Westboro†	85	18	48.9	2.43	
Worcester *b*	80	21	48.1	2.65	T.
Michigan.					
Adrian	78	17	46.7	3.06	2.5
Allegan	80	10	45.2	2.70	T.
Alma	74	14	43.0	3.17	T.
Ann Arbor	78	16	44.8	3.07	T.
Arbela	73	16	44.4	2.62	.....
Baldwin	71	10	41.7	4.49	T.
Ball Mountain	75	13	42.4	1.51	1.3
Baraga	75	9	37.2	1.88	1.3
Battlecreek	79	16	45.2	2.18	0.3
Bay City *b*	73	20	46.3	3.61	T.
Benton Harbor	78	18	45.8	2.07	T.
Benzonia	70	15	43.0	3.15	T.
Berlin	75	15	42.6	1.92	1.8
Berrien Springs	80	17	45.7	2.26	4.0
Big Rapids	73	13	42.0	4.56	T.
Birmingham	76	18	45.2	2.67	0.5
Boon	69	6	38.6	5.39	0.5
Calumet	73	5	37.6	2.29	1.5
Camden	78	17	44.9	2.67	4.0
Carsonville	75	18	44.1	1.04	.....
Charlevoix	74	14	41.7	1.50	T.
Cheboygan	74	10	39.6	3.06	T.
Clinton	79	15	45.2	2.25	1.7
Cold Water	77	15	44.9	2.65	0.0
East Tawas	68	15	40.2	4.06	T.
Eloise	77	18	45.0	2.00	T.
Escanaba†	64	12	37.4	2.35	2.0
Ewen	75	9	38.1	1.47	2.5
Fairview	78	11	43.0	1.38	1.2
Fitchburg	76	12	43.3	1.77	T.
Flint	76	16	42.2	2.06	.....
Gladwin	71	15	41.0	5.90	T.
Grand Rapids *b*	78	13	44.0	3.07	T.
Grape	78	18	46.0	3.09	2.5
Grayling	72	5	40.8	4.57	1.0
Hanover	75	13	44.9	2.93	1.5
Harrison	76	8	40.7	4.12	0.5
Harrisville	75	13	39.4	5.22	4.3
Hart	69	18	44.0	4.16	0.2

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Michigan—Cont'd.	°	°	°	*Ins.*	*Ins.*
Hastings	73	16	44.4	2.95	0.5
Hayes	74	17	42.0	3.08	.....
Highland Station	75	16	44.3	2.07	1.0
Hillsdale	78	10	44.6	2.09	T.
Holland *10	59	18	44.6	.....	.....
Howell	74	15	44.5	2.25	T.
Humboldt	71	5	35.1	0.93	1.0
Ionia	75	16	44.8	2.66	.....
Iron River	72	6	37.2	2.60	1.5
Ivan	70	10	39.8	5.72	1.0
Jackson	77	17	44.9	1.32	.....
Jeddo	74	19	42.6	1.90	0.2
Kalamazoo	78	16	45.4	3.17	T.
Lake City	71	10	40.0	5.78	T.
Lansing	75	15	43.6	2.40	0.8
Lapeer	74	15	44.0	2.30	0.5
Lathrop	74	5	36.2	1.68	2.0
Ludington	67	19	43.0	1.08	T.
Luzerne	75	7	38.0	5.56	3.0
Mackinaw City	72	10	37.6	2.98	.....
Madison	78	16	45.9	2.90	2.3
Mancelona	75	8	40.4	5.74	1.0
Manistee	69	16	41.3	4.00	.....
Manistique	60	11	35.4	3.18	1.2
Mayville	74	16	43.2	2.20	T.
Middle Island *10	67	15	39.2	.....	.....
Midland	.....	.....	.....	2.63	.....
Mottville	79	11	46.2	3.05	T.
Mount Clemens	76	17	44.4	.....	T.
Mount Pleasant *b*	72	19	43.0	2.95	T.
Muskegon	73	18	42.8	2.81	T.
Newberry	65*	0	33.5*	2.25	1.0
North Manitou Island *10	64	15	39.0	.....	.....
North Marshall	77	13	43.4	2.56	T.
Northport	72	15	40.6	2.85	T.
Old Mission	70	15	40.8	4.14	1.0
Olivet	75	17	44.8	2.42	0.3
Ovid	75	16	43.9	2.35	1.0
Owosso	76	10	44.2	3.05	.....
Parkville	.....	.....	.....	2.87	1.0
Petoskey	72	13	40.0	4.03	.....
Plymouth	77	11	44.2	2.10	T.
Point Aux Barques *10	76	21	40.8	.....	.....
Port Austin	75	12	40.6	2.85	.....
Powers	74	10	39.2	1.90	0.0
Reed City	72	10	40.6	4.67	.....
Rockland	76	5	39.6	1.40	1.2
Rogers City	75	7	37.5	5.81	0.5
Romeo	73	21	45.5	0.88	0.0
Saginaw	75	17	44.0	2.65	.....
St. Ignace	.....	.....	.....	3.28	.....
St. Johns	75	15	44.6	2.20	1.0
Sandbeach *b*	74	12	40.2	3.54	0.1
Saranac	78	13	45.4	2.65	2.0
Sidnaw	70	8	37.6	0.94	.....
Somerset	76	15	43.9	2.41	1.2
South Haven	79	18	43.5	1.99	.....
Stanton	75	12	42.4	2.86	T.
Thomaston	74	6	37.8	1.44	3.0
Thornville	74	17	45.9	1.33	3.4
Thunder Bay Island *10	58	13	37.7	.....	.....
Traverse City	74	20	44.6	5.00	0.0
Valley Center	75	15	42.4	2.64	2.5
Vandalia	79	16	46.6	2.57	2.1
Wasepi	79	15	44.8	2.10	0.0
Waverly	78	14	44.3	2.56	0.3
West Harrisville	71	15	39.2	4.45	0.2
Wetmore	73	3	36.2	2.09	7.0
White Cloud	72	13	42.2	3.74	0.1
Ypsilanti	77	16	45.4	2.47	1.0
Minnesota.					
Ada†	88	13	44.6	0.70	T.
Alexandria†	82	9	42.4	1.57	T.
Beardsley†	90	17	45.2	1.76	.....
Belleplaine *1	70	28	42.4	1.95	T.
Bermidji	.....	.....	.....	0.90	2.7
Bingham Lake	76	20	45.7	.....	.....
Bird Island	78	18	44.9	1.66	2.0
Blooming Prairie†	75	21	44.0	1.45	T.
Bonniwell	80	19	45.8	1.30	.....
Caledonia†	73	20	46.2	2.32	T.
Camden	83	18	45.2	3.63	5.0
Campbell	89	15	43.4	0.92	.....
Collegeville	80	17	44.9	2.02	1.0
Crookston†	75	14	45.6	0.39	T.
Dawson *1	86	30	41.4	1.55	2.0
Detroit City	86	11	42.3	1.75	T.
Faribault	75	22	44.4	1.66	.....
Farmington†	80	18	42.8	2.15	4.0
Fergus Falls†	86	15	43.5	1.33	0.5
Glencoe†	78	0	42.7	1.44	.....
Glenwood†	82	15	42.6	2.49	.....
Grand Meadow†	75	20	44.3	1.64	2.0
Grand Portage	47	9	31.6	2.16	.....
Granite Falls	83	18	45.0	2.32	.....
Koochiching	81	5	38.8	0.28	T.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Minnesota—Cont'd.	°	°	°	*Ins.*	*Ins.*
Lake City	80	18	45.9	0.86	T.
Lakeside†	79	20	45.0	2.50	2.0
Lake Winnibigoshish [1]	79*	11	38.5	1.03	3.8
Lambert†	80	11	40.2	T.	T.
Lawrence	80	16	43.7	.....	.....
Leech Lake [1]	82*	11	41.0	1.46	.....
Lesueur *1	80	20	48.4	1.97	.....
Long Prairie†	86	14	43.0	1.57	0.8
Luverne†	80	19	45.6	2.35	1.0
Mapleplain	80	19	45.2	1.38	1.6
Maplewood *1	77	25	45.1	.....	.....
Mazeppa [1]	80*	18	42.2	0.90	T.
Milaca [1]	92	12	44.4	.....	.....
Milan†	88	17	45.2	2.29	2.0
Minneapolis *a*†	78	20	45.2	1.61	0.9
Minneapolis *b* [1]	76*	20	44.0	1.52	1.5
Minnesota City *†1	80	24	47.4	2.35	.....
Montevideo†	87	18	44.4	1.91	0.5
Morris	84	18	44.0	2.53	0.5
Mount Iron	78	8	39.2	0.30	2.0
New London	80	12	40.2	0.93	0.5
New Richland *14	76	24	46.0	.....	.....
New Ulm†	80	20	45.8	2.95	0.5
Park Rapids†	85	10	41.0	2.00	4.0
Pine River [1]	72*	10	42.2	1.39	0.2
Pleasant Mounds†	80	23	46.0	3.54	T.
Pokegama Falls [1]	63*	8	42.3	1.63	.....
Redwing	.....	.....	.....	1.14	.....
Reeds	.....	.....	.....	1.64	.....
Rolling Green	75	21	43.4	4.65	.....
Roseau	75	9	39.4	0.24	1.3
St. Charles†	75	19	44.9	2.20	2.0
St. Cloud	75	15	41.4	1.56	.....
St. Olaf	86	15	43.2	1.35	.....
Sandy Lake Dam [1]	75*	12	41.1	0.53	.....
Sauk Center	81	10	42.7	1.96	T.
Shakopee [6]	78*	24	47.5	1.19	0.5
Tower†	77	— 3	35.5	0.70	4.0
Two Harbors†	71	14	40.0	1.18	0.5
Wabasha *1	79	23	47.9	1.47	T.
Willmar†	81	18	44.1	0.84	0.5
Worthington	78	14	42.3	2.82	T.
Zumbrota [1]	74*	15	45.5	.....	.....
Mississippi.					
Aberdeen	88	31	61.0	2.85	.....
Agricultural College	84	39	62.6	2.41	.....
Austin†	84	41	62.2	5.20	.....
Batesville†	83	35	60.6	2.68	.....
Bay St. Louis	81	47	68.2	8.75	.....
Biloxi†	83	47	66.7	4.69	.....
Briers†	82	47	65.0	2.60	.....
Brookhaven†	90	36	65.5	1.84	.....
Canton†	85	40	65.2	2.53	.....
Columbus *a*†	.....	.....	.....	3.59	.....
Columbus *b*	90	35	63.8	3.47	.....
Corinth†	90	30	58.6	4.12	.....
Crystal Springs†	89	38	65.4	1.81	.....
Edwards	88	39	65.7	1.92	.....
Enterprise	88	37	64.5	4.89	.....
Fayette†	94	37	67.2	1.48	.....
French Camps†	88	30	61.8	1.42	.....
Fulton†	86	32	61.6	3.37	.....
Greenville *a*	81	45	63.4	1.97	.....
Greenville *b*†	84	42	64.7	1.96	.....
Hattiesburg†	86	42	66.6	3.28	.....
Hernando	85	40	60.2	2.54	.....
Holly Springs	86	38	61.1	4.04	.....
Jackson†	87	37	63.8	1.54	.....
Lake	84	37	61.9	2.87	.....
Leakesville†	89	40	65.8	5.47	.....
Logtown†	84	46	68.0	4.63	.....
Louisville†	87	34	62.6	2.34	.....
Macon†	89	37	63.4	1.70	.....
Magnolia†	88	39	65.6	3.69	.....
Mayersville	84	41	65.8	1.20	.....
Meridian†	87	37	63.2	3.04	.....
Mosspoint	83	46	66.4	2.75	.....
Natchez†	86	40	66.6	4.50	.....
Okolona	91	36	62.4	2.03	.....
Palo Alto†	87	39	63.0	1.62	.....
Pontotoc	88	36	59.2	2.02	.....
Port Gibson†	88	37	65.4	3.28	.....
Stonington *1	86	42	65.6	.....	.....
Thornton†	94	46	66.8	1.65	.....
Topton *5	84	42	66.4	1.70	.....
University	91*	37*	62.8*	2.38	.....
Water Valley *†1	88	34	60.3	2.89	.....
Waynesboro *b*	85	45	66.0	2.85	.....
Woodville†	83	41	65.6	3.01	.....
Yazoo City†	88	39	66.8	2.20	.....
Missouri.					
Akron	.. ..	.....	.....	4.63	.....
Arlington†	.....	.....	.....	6.34	.....
Arthur *†5	.....	35	54.6	4.01	.....
Avalon	82	30	53.6	4.26	.....
Bagnell†	.....	.....	.....	5.95	.....

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Missouri—Cont'd.	°	°	°	*Ins.*	*Ins.*
Birchtree	87	29	56.2	6.40	.....
Bolckow†	.....	.....	.....	4.29	T.
Boonville†	.....	.....	.....	8.21	.....
Brunswick	82	32	52.6	4.16	.....
Carrollton†	83	34	54.8	3.08	.....
Conception	79	37	52.0	4.51	.....
Cowgill *5	78	32	52.7	5.14	.....
Darksville†	83	32	52.6	3.00	.....
Downing	.....	.....	.....	2.95	.....
East Lynne *3	.....	34	51.8	1.80	.....
Edgehill *5	80	34	55.5	7.00	.....
Eightmile *1	81	34	53.4	1.85	T.
Elmira	85	25	53.4	5.09	.....
Emma *3	.....	30	53.7	1.20	.....
Fairport	.....	.....	.....	4.03	.....
Farmersville	.....	.....	.....	4.37	.....
Fayette	83	34	55.0	3.69	.....
Fulton	.....	.....	.....	5.56	.....
Gallatin *1	79	30	52.2	4.51	.....
Glasgow	82	30	53.8	2.28	.....
Gordonville *3	.....	37	54.6	6.23	.....
Gorin	.....	.....	.....	4.54	T.
Halfway	85	28	54.9	4.80	.....
Harrisonville†	85	30	53.6	1.67	.....
Hastain	85	30	55.8	3.96	.....
Hermann†	.....	.....	.....	4.78	T.
Houston	83	30	56.8	5.99	.....
Houstonia	.....	.....	.....	2.17	.....
Irena	.....	.....	.....	5.78	.....
Ironton†	86	28	55.7	7.64	.....
Jefferson City†	83	32	56.2	2.95	.....
Kidder	81	29	52.2	4.37	.....
Lamar†	85	31	56.4	3.87	.....
Lamonte	.....	.....	.....	2.39	.....
Lebanon	83	32	55.8	4.76	.....
Lexington†	85	31	54.9	3.13	.....
Liberty	85	33	54.5	3.64	.....
McCune *†1	82	33	52.7	4.78	.....
Mansfield	.....	.....	.....	5.00	.....
Marblehill	83	30	55.0	6.58	.....
Marshall†	88	31	53.2	2.38	.....
Maryville	81	28	50.0	6.63	.....
Mexico†	84	32	54.1	3.84	.....
Mine La Motte†	81	32	56.0	6.40	.....
Mineralspring	85	32	56.4	5.96	.....
Montreal *1	84	35	54.7	4.06	.....
Mount Vernon	86	30	57.3	3.65	.....
Neosho	81	.....	.....	3.58	.....
Nevada *1	82	32	55.8	3.48	.....
New Haven *1	78	38	56.4	4.01	.....
New Madrid	73	36	56.4	8.08	.....
New Palestine *†1	79	37	56.2	4.19	.....
Oakfield	82	34	55.8	6.70	.....
Oakmound	.....	.....	.....	4.71	.....
Oakridge *4	.....	37	55.4	5.76	.....
Olden†	81	30	55.3	6.27	.....
Oregon *a*	82	31	54.2	4.25	T.
Oregon *b* *1	82	30	51.8	4.19	.....
Osceola†	.....	.....	.....	5.30	.....
Oto	.....	.....	.....	4.20	.....
Palmyra *5	80	32	52.3	3.49	.....
Phillipsburg *†1	82	32	53.5	4.74	.....
Pickering *3	.....	32	50.4	3.99	.....
Platte River *3	82	30	50.6	6.65	.....
Poplar Bluff	84	32	58.6	5.63	.....
Potosi	79	21	49.2	5.67	T.
Princeton	80	29	51.6	3.16	.....
Rhineland	80	32	56.0	4.80	.....
Richmond	80	32	52.7	3.09	.....
Rolla	.....	.....	.....	5.01	T.
St. Charles	81	32	54.2	4.81	.....
St. James *3	.....	37	52.8	.....	.....
St. Joseph†	.....	.....	.....	5.02	.....
St. Louis	79	34	54.4	6.17	.....
Sarcoxie *3	.....	32	53.6	3.04	.....
Sedalia	85°	37°	53.5°	3.18	.....
Seymour *1	80	30	53.7	7.15	.....
Shelbina	.....	.....	.....	4.30	T.
Sikeston	81	37	59.2	7.43	.....
Stellada†	87	29	55.2	2.89	.....
Sublett	80	27	51.2	4.77	.....
Trenton	80	31	52.8	3.44	.....
Unionville	85	30	53.2	3.50	.....
Vichy	82	28	55.8	4.87	.....
Virgil City	.....	.....	.....	2.87	.....
Wheatland	.....	.....	.....	4.16	.....
Willow Springs	83	28	55.2	6.97	.....
Zeitonia *1	83	33	57.1	5.40	.....
Montana.					
Augusta†	82	14	46.6	1.11	8.7
Bigtimber†	76	23	47.1	0.44	.....
Boulder	76*	16*	42.6*	.....	.....
Bozeman†	83	21	44.4	1.58	3.0
Bozeman Exper. Stat'n.	73	19	43.0	1.44	.....
Butte†	72	20	41.6	1.63	15.5
Castle	70	19	40.0	0.54	5.4

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Montana—Cont'd.	°	°	°	*Ins.*	*Ins.*
Chinook†	88	28	50.0	0.30	
Choteau†	79[d]	25[e]	45.8[d]	0.93	T.
Cokedale	75	19	43.2	0.86	4.6
Columbia Falls	76	23	46.0	0.99	0.5
Deer Lodge	74	20	42.2	0.24	1.0
Ekalaka	83	21	42.3	0.57	0.4
Fort Benton	86	25	50.1	1.15	T.
Fort Custer†	86	19	45.6	1.16	10.0
Fort Keogh†	89	24	47.2	0.41	2.0
Fort Logan†	75	19	42.1	0.82	
Fort Missoula	80	22	46.8	1.46	
Glasgow	88	21	46.8	0.69	
Glendive†	94	28	49.1	0.40	1.0
Greatfalls†	88	28	51.2	1.09	0.9
Hogan†	75	15	43.0	1.50	15.0
Kalispell	77	28	46.9	0.77	.....
Kipp†	77	18	43.5	1.60	12.4
Lewiston	80	20	43.6	1.10	7.0
Libby†	86	21	49.5	0.83	3.0
Livingston†	81	21	45.6	0.52	T.
Manhattan†	77	19	44.6	0.30	1.0
Martinsdale†	75	19	42.8	0.72	6.5
Marysville†	74	17	42.2	0.83	5.6
Monarch	81	7	43.1	2.38	12.8
Poplar†	88	24	45.4	0.71	
Radersburg	.....	.....	.....	1.75	
St. Ignatius Mission†	76	18	48.2	0.88	
St. Pauls†	80	20	43.7	1.30	
Sun River	83	23	47.4	1.40	6.0
Troy	85	24	49.4	0.68	
Utica†	76	18	42.4	.....	.....
Virginia City†	71	20	41.5	1.29	10.0
Wibaux†	84	20	45.2	0.30	T.
Yale†	79	17	41.8	1.21	7.5
Nebraska.					
Agee*[1]	85	26	46.0	4.08	
Albion	89	26	51.2	4.63	
Alliance*[1]	78	19	43.9	2.13	15.0
Ansley†	82	22	47.2	5.00	
Arapaho*[1]	80	30	49.7	5.69	
Arborville*[1]	80	27	48.3	4.80	
Arcadia	90	28	49.2	7.04	
Ashland *a*†	78	28	50.3	7.29	
Ashland *b**[1]	82	30	49.9	6.82	
Ashton	80	27	48.8	5.01	
Auburn*†	84	28	52.6	4.54	
Aurora*[1]	82	32	50.6	3.79	0.8
Bassett	84[c]	20[c]	46.9[c]	1.92	
Beatrice†	81	29	50.2	6.54	
Beaver City†	87	29	51.2	5.30	T.
Benkelman	.....	.....	.....	1.12	
Bluehill*[1]	80	33	50.7	5.92	
Brokenbow*[1]	78	30	49.2	5.40	3.5
Burchard	.....	.....	.....	7.15	
Burwell	.....	.....	.....	3.24	T.
Callaway†	80	25	47.2	5.30	5.5
Central City*[5]	79	36	55.2	6.10	
Chester*[1]	82	34	48.6	4.99	
Columbus†	78	27	49.0	5.10	
Cornlea	.....	.....	.....	4.64	
Creighton†	84	23	46.6	5.88	
Crete	79	29	50.8	4.38	
Culbertson	.....	.....	.....	4.73	0.8
Curtis *a*	89	28	50.3	5.10	3.0
David City*†	76	33	48.2	6.60	
Divide	.....	.....	.....	4.23	
Dunning*[1]	77	31	46.4	3.11	
Eden	.....	.....	.....	4.72	
Edgar*[1]	78	33	49.1	5.02	
Elba	.....	.....	.....	4.33	
Ericson*†	80	33	47.8	4.25	
Ewing†	.....	.....	.....	4.34	
Fairbury†	84	28	51.6	3.35	
Fairmont†	80	28	49.0	4.72	
Filley	.....	.....	.....	3.74	
Fort Robinson	82	23	44.0	0.40	T.
Fremont†	79	26	48.8	5.61	
Geneva†	83	29	51.9	4.69	T.
Genoa	78	28	48.6	5.47	
Gering†	84	16	46.6	1.40	7.5
Gothenburg	84	24	49.6	4.85	T.
Grand Island *a**[1]	84	36	51.4	5.72	
Grand Island *b*	79	28	49.0	7.01	
Greeley*[1]	80	34	48.4	6.15	
Haigler*[1]	82	30	47.8	2.58	3.0
Hartington†	83	23	46.7	4.48	
Harvard*[1]	81	31	49.4	4.19	
Hastings*[1]	81	34	49.6	4.80	
Hayes Center	.....	.....	.....	3.36	
Hay Springs	83	24	44.7	1.65	9.1
Hebron†	83	27	51.1	3.12	
Hickman	.....	.....	.....	4.13	
Holdrege *a*	.....	.....	.....	4.02	
Holdrege *b*[1]	84	33	51.8	5.80	
Imperial *a*†	88	20	48.2	2.55	10.0
Indianola (near)*[1]	84	30	48.5	5.23	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Nebraska—Cont'd.	°	°	°	*Ins.*	*Ins.*
Kearney*[5]	82	30	50.0	6.52	
Kennedy	84	21	46.0	1.80	2.5
Kimball†	79	8	44.2	1.10	11.0
Kirkwood*[1]	82	27	46.6	2.69	3.0
Lexington†	83	17	46.2	4.24	.....
Lincoln *b*†	80	31	51.3	6.51	
Lincoln *d*	80	32	49.3	5.28	
Lodgepole†	89	13	46.3	2.10	
Loup *a**[1]	77	32	50.3	4.69	
Loup *b**[1]	88	30	47.9	4.80	
Lynch*†[1]	87	26	47.8	5.90	3.2
Lyons	80	24	45.3	4.43	
McCook*[1]	87	32	48.8	3.27	0.1
McCool	.....	.....	.....	5.35	
Madison*[1]	82	25	45.2	3.85	
Madrid*[5]	85	18	47.8	2.19	14.0
Marquette	.....	.....	.....	4.48	T.
Minden *a*[1]	84	30	48.4	4.48	1.5
Minden *b*	.....	.....	.....	5.45	.....
Nebraska City *a*	80	28[k]	50.4[f]	3.50	
Nebraska City *b*[1]	82	32	51.2	3.69	
Nemaha*[1]	83	32	49.6	4.38	
Nesbit	84	22	45.5	2.84	9.5
Norfolk*†[5]	75	22	44.0	3.86	T.
Norman	80	27	49.4	5.03	
North Loup†	79	27	47.4	6.05	
Oakdale†	80	24	47.0	3.36	0.5
Odell*[5]	80	32	52.6	4.33	
O'Neill†	81	23	45.6	4.85	
Ord	.....	.....	.....	4.63	
Osceola	.....	.....	.....	6.74	
Ough†	.....	.....	.....	2.85	
Palmer *b*	.....	.....	.....	4.44	
Plattsmouth *a*†	.....	.....	.....	5.47	
Ravenna *a*	79	27	49.0	5.21	0.5
Ravenna *b**[1]	78	32	45.8	5.19	.....
Redcloud *a*	.....	.....	.....	4.97	
Redcloud *b*[1]	82	30	52.2	4.50	
Republican*[1]	86	34	51.3	4.04	
Rulo*[1]	84	37	54.5	5.12	
St. Libory	80	26	48.8	4.34	
St. Paul	80	30	50.8	4.59	
Salem*[1]	66	32	53.6	.....	
Santee Agency†	85	34	47.8	4.32	T.
Sargent	.....	.....	.....	3.77	
Schuyler	.....	.....	.....	6.25	
Seneca*[1]	87	27	46.4	3.93	
Seward*[1]	76	33	49.9	7.31	
Springfield*[1]	80	29	49.1	6.78	
Springview	83	25	45.8	1.31	10.0
Stanton*[1]	80	27	47.8	4.92	
State Farm	80	29	51.1	5.08	
Strang*[1]	84	34	52.4	5.27	
Stratton	.....	.....	.....	2.50	
Stromsburg	.....	.....	.....	3.56	
Superior*[5]	80	32	52.0	5.64	
Sutton	78	30	49.0	6.21	
Syracuse	.....	.....	.....	3.42	
Tecumseh *b*†	83	28	53.4	5.32	
Tekamah	80	26	50.1	5.09	
Thedford*[1]	80	28	45.0	3.70	4.0
Turlington†	80	27	49.6	4.10	
Valentine†	82	24	45.3	2.19	
Wakefield	78	24	47.2	4.26	
Wallace*[1]	92	17	43.7	2.23	15.0
Wayne	.....	.....	.....	5.15	
Weeping Water*[1]	80	26	47.6	3.97	
Westpoint†	78	29	49.6	6.04	
Whitman	.....	.....	.....	1.68	1.0
Wilber*[1]	80	38	58.3	8.72	
Willard	.....	.....	.....	2.73	
Wilsonville*[1]	80	26	45.6	6.61	T.
Wisner	.....	.....	.....	4.93	
Woodlawn	.....	.....	.....	5.90	
York*[1]	76	32	49.4	5.45	
Nevada.					
Austin	70	19	44.8	0.94	4.0
Battle Mountain*[1]	80	30	47.4	0.36	3.0
Beowawe*[1]	84	30	49.0	0.09	1.0
Candelaria[f]	78	14	49.2	T	
Carlin*[1]	83	18	42.0	0.25	T.
Carson City	80	24	48.7	0.04	0.2
Cloverdale*[1]	73	21	53.6	T.	
Clover Valley	.....	.....	.....	1.06	4.0
Cranes Ranch	.....	.....	.....	1.44	5.5
Darrough Ranch	.....	.....	.....	0.05	
Downeyville	91	28	57.0	0.47	T.
Duckwater	80	17	46.8	0.61	T.
Elko*[3]	80	28	43.7	0.52	2.0
Elko (near)	.....	.....	.....	0.60	
Ely	74	11	41.9	0.75	1.5
Empire Ranch	79	20	46.6	0.16	1.0
Fenelon*[1]	76	21	44.0	0.85	8.5
Golconda*[1]	84	28	49.4	0.30	2.0
Gold Creek	68	9	37.2	0.14	1.5
Halleck*[1]	82	28	42.6	0.36	1.2

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Nevada—Cont'd.	°	°	°	*Ins.*	*Ins.*
Hamilton	82	8	40.8	0.35	3.5
Hawthorne *a*[3]	78	32	55.3	T.	
Hawthorne *b*	81	29	52.8	0.10	T.
Hot Springs*[1]	82	35	50.3	T.	
Humboldt*[1]	83	29	52.3	0.19	1.0
Keysers Springs	.....	.....	.....	0.40	
Lewers Ranch	78	22	41.9	0.25	0.5
Lovelock*[1]	86	22	54.4	0.09	1.0
McGill	77	19	44.9	0.45	1.0
Midas	74	24	46.4	0.75	4.0
Mill City*[1]	87	32	49.8	0.00	
Monitor Mill	76	11	41.0	0.67	6.7
Osceola	80	30	46.1	0.39	1.0
Palisade*[1]	73	26	46.5	0.37	4.0
Palmetto	75	17	46.0	0.05	
Reno*[3]	80	28	50.0	0.00	
Reno State University	79	26	48.4	0.03	T.
Ruby Valley	.....	.....	.....	1.06	1.1
San Antonio	83	19	51.4	T.	T.
Silver Peak	85	25	55.9	T.	T.
Sodaville	84	15	51.6	0.30	
Tecoma*[1]	85	28	44.3	0.50	
Toano*[1]	82	26	45.7	1.15	4.0
Tuscarora	73	10	38.0	0.94	4.2
Tybo	83	17	47.7	T.	T.
Verdi*[1]	75	30	50.6	T.	T.
Wadsworth*[1]	86	26	47.4	0.00	
Wells	77	22	44.1	1.09	
New Hampshire.					
Bethlehem	80	8	42.2	2.65	15.0
Concord	85	17	47.3	2.38	T.
Durham	85	17	46.6	2.50	
Grafton†	85	12	43.6	2.27	2.0
Hanover	79	15	43.0	2.60	4.5
Keene	84	16	45.1	2.74	T.
Lancaster	80	12	41.6	2.30	
Nashua	87	18	47.9	1.88	
Newton	85	18	46.8	1.95	T.
North Conway	83	14	44.7	2.43	5.0
Peterboro	84	15	45.6	2.08	T.
Plymouth	84	14	44.4	1.60	1.5
Sanbornton†	83	13	43.6	2.55	2.0
Stratford	88	10	42.8	2.90	T.
Warner	.....	.....	.....	2.35	T.
West Milan	84	5	41.6	2.95	T.
New Jersey.					
Allaire	81	26	52.3	.....	
Asbury Park	70	26	50.5	4.36	
Barnegat	78	28	51.0	6.82	
Bayonne	79	26	51.2	3.87	T.
Beachhaven	66	29	48.8	3.10	
Belvidere	87	23	50.4	4.15	
Beverly†	80	25	52.4	3.35	
Billingsport*[1]	85	29	50.9	3.48	
Blairstown	83	25	51.0	3.75	
Boonton	85	21	50.0	3.49	T.
Bridgeton	86	29	53.5	5.06	
Camden	86	27	52.2	3.44	
Cape May	70	30	50.0	3.55	
Cape May C. H.†	71	29	49.8	3.36	
Charlotteburg	83	21	47.7	3.54	
Chester	79	20	47.6	3.79	2.0
Clayton	85	26	51.2	4.06	
College Farm†	85	26	51.2	3.47	T.
Deckertown	85	22	50.0	3.08	
Dover	82	22	48.6	3.03	T.
Egg Harbor City	80	23	50.0	4.86	
Egg Island	64	28	50.8	2.17	
Elizabeth†	85	24	51.4	3.54	T.
Englewood	80	23	49.2	2.54	
Franklin Furnace	84	21	49.2	3.69	
Freehold	82	23	50.2	4.18	
Friesburg	.....	.....	.....	4.03	
Gillette	84	22	48.3	3.24	2.0
Hammonton	.....	.....	.....	5.79	
Hanover	81	24	49.4	3.54	
Hightstown	88	25	52.1	3.93	
Imlaystown	86	25	51.7	3.59	T.
Junction	.....	.....	.....	2.85	0.5
Lambertville	84	25	51.3	3.81	
Moorestown	85	26	51.7	4.00	
Newark *a*	79	25	50.1	3.41	.....
Newark *b*†	82	25	50.9	3.66	T.
New Brunswick *a*	88	25	52.8	3.48	.....
New Brunswick *b*	84	25	49.7	3.49	T.
Newton	85	21	48.8	3.79	
Ocean City	65	28	49.4	3.77	
Oceanic	76	29	53.4	4.50	T.
Paterson	82	26	52.6	3.27	
Plainfield	84	24	49.3	3.91	T.
Rancocas	.....	.....	.....	3.81	
Readington*[3]	80	30	53.7	.....	
Rivervale	80	21	48.1	2.34	
Sergeantsville	81	24	49.2	3.43	
Somerville	86	19	50.8	3.92	
South Orange	84	25	49.7	2.47	T.

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
New Jersey—Cont'd.	°	°	°	*Ins.*	*Ins.*
Staffordville	.....	.....	.....	6.98	
Toms River	80	30	49.7	5.30	
Trenton	82	29	53.4	3.51	
Vineland	85	25	51.9	5.18	
Woodbine	80	21	50.0	3.68	
New Mexico.					
Albert	84	29	56.1	0.32	
Albuquerque†	80	27	55.7	0.63	
Alma	87	21	53.6	0.15	
Angus V. V. Ranch	75	20	49.0	0.55	0.5
Aztec†	80	18	46.6	0.23	
Bernalillo†	88	29	56.2	0.55	
Bluewater†	76	14	46.5	0.50	T.
Buckmans	65	5	38.4	1.35	3.5
Chama†	78	9	42.9	0.79	8.0
Clayton	79	29	50.2	1.05	
Deming*[8]	90	33	58.3	0.00	
East Lasvegas†	73	22	49.0	0.37	0.2
Eddy	91	31	61.9	0.43	
Engle†	83	31	57.4	1.56	
Espanola†	81	23	50.2	0.16	T.
Fort Bayard	80	25	53.4	0.10	
Fort Union	75	15	45.0	0.70	3.0
Fort Wingate	77	19	48.4	0.11	
Gallisteo†	76	21	51.5	0.00	
Gallinas Spring†	83*	26*	55.2*	0.02	
Gila	89	28	59.3	T.	
Gold Hill†	48	1	25.0	2.20	16.5
Hillsboro†	85	34	60.0	0.20	
Labelle†	63	7	36.3	0.86	8.5
Las Cruces†	88	21	58.1	0.23	
Lordsburg*[8]	83	39	62.7	0.00	
Los Lunas†	89	20	54.3	0.50	
Lower Penasco[1]	79	27	54.2	0.50	T.
Monero†*	78	11	42.4	0.84	
Ocate†	72	11	45.7	0.61	2.5
Ollo	81	23	50.9	T.	
Puerto de Luna†	87	29	58.7	0.35	
Raton†	75	18	46.0	0.20	2.0
Rincon†	87	30	60.6	0.18	
Roswell†	88	28	59.4	1.35	
San Marcial†	95	33	61.2	0.37	
Shattucks Ranch	86	27	55.9	0.81	T.
Socorro†	85	30	56.7	1.00	
Springer†°	79	14	48.4	0.10	T.
Valley Ranch	75	18	46.0	T.	
White Oaks†	76	28*	51.7*	0.45	T.
Winsors Ranch	66	13	39.8	1.37	1.5
New York.					
Addison	81	30	46.2	2.41	T.
Akron	.....	.....	.....	1.79	.....
Alfred	76	14	43.0	2.69	4.1
Angelica†	79	16	43.4	3.15	3.0
Appleton	77	22	44.5	2.58	1.0
Arcade	76	15	43.0	3.06	6.5
Atlanta	.....	.....	.....	1.92	.....
Avon	80	19	45.4	1.21	
Baldwinsville	81	21	46.6	2.18	T.
Bedford	77	20	48.2	3.22	.....
Big Sandy*[10]	71	18	42.6	.....	.....
Binghamton†	81	18	45.9	2.33	0.2
Bolivar	78	16	43.6	2.48	2.0
Boyds Corners	.....	.....	.....	2.78	
Brentwood	77	17	47.2	4.90	
Brooklyn	73	26	50.8	2.75	T.
Canajoharie	84	18	45.8	1.56	T.
Canton	76	13	43.3	3.16	3.0
Carmel	81	20	49.0	3.05	
Catskill	83	22	47.8	3.20	
Charlotte*[10]	70	20	40.7	.....	.....
Cherry Creek	.....	.....	.....	3.11	.....
Cooperstown†	81	15	43.2	3.65	T.
Cortland	74	18	43.2	0.68	
De Kalb Junction	.....	.....	.....	2.81	.....
Dryden	82	18	44.2	2.82	
Eagle Mills	.....	.....	.....	4.97	.....
Elizabethtown	86	12	42.2	4.75	14.5
Elmira†	84	23	48.3	2.30	
Fleming	83	20	45.7	2.21	
Fort Niagara†	78	22	45.2	2.49	
Franklinville	76	14	44.0	2.76	5.2
Friendship	81	18	45.3	2.77	0.5
Fulton	.....	.....	.....	2.42	.....
Garrattsville	89	9	44.0	3.15	T.
Glens Falls	86	17	44.9	3.61	2.0
Gloversville	84	15	44.0	3.38	T.
Haskinsville	.....	.....	.....	2.25	.....
Honeymead Brook	84	19	46.4	3.33	T.
Humphrey†	77	15	43.6	1.39	7.5
Ithaca	82	20	46.2	2.47	0.5
Jamestown	75	20	45.7	3.77	6.0
Kings Station	.....	.....	.....	3.68	.....
Lake George	84	17	45.0	3.85	3.0
Little Falls	82	15	44.1	4.47	T.
Lockport	78	22	46.4	1.98	5.0
Lowville	78	14	42.6	2.97	4.0

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
New York—Cont'd.	°	°	°	*Ins.*	*Ins.*
Lyons	81	21	46.0	2.14	2.0
Madison Barracks†	74[1]	16	47.5	1.16	.....
Manhatton Beach	66	30	46.0	3.26	
Middletown[f]	84	30	49.8	.....	
Mohonk Lake	79	14	45.0	2.12	
Mount Morris	.....	.....	.....	2.10	T.
Newark Valley	.....	.....	.....	3.08	.....
New Lisbon	80	13	42.3	2.63	T.
Niagara Falls	.....	.....	.....	3.09	.....
North Hammond†	74	14	44.0	2.57	3.8
North Lake	75	10	37.2	3.80	4.5
Number Four†	76	9	40.4	3.93	10.3
Ogdensburg	72	13	44.2	3.98	1.5
Oneonta	83	16	46.4	3.26	
Oxford	83	16	44.4	3.76	
Palermo†	81	19	44.1	1.49	T.
Perry City	82	16	43.2	2.56	0.5
Phœnix	.....	.....	.....	2.39	.....
Pine City	.....	.....	.....	2.95	.....
Pittsford	80	30	45.3	2.23	
Plattsburg Barracks†	84	14	42.2	2.67	
Port Jervis	87	21	49.5	3.11	
Poughkeepsie	83	30	48.0	1.30	T.
Primrose	77	23	49.2	2.88	
Ridgeway	78	21	45.2	2.62	4.0
Rome	82	18	45.6	3.36	
Romulus	82	19	47.0	2.53	2.8
Rose	.....	.....	.....	2.52	.....
St. Johnsville	80	17	44.1	2.30	
Saranac Lake	79	9	41.5	3.79	7.2
Scottsville	.....	.....	.....	1.98	.....
Setauket†	74	26	48.7	3.29	
Sherwood	.....	.....	.....	2.47	.....
Skaneateles	.....	.....	.....	3.16	.....
South Canisteo	82	15	44.5	3.13	4.0
Southeast Reservoir	.....	.....	.....	3.05	
South Kortright†	81	12	42.8	2.91	
Straits Corners	81	12	44.2	2.68	1.5
Wappingers Falls	83	23	49.6	3.05	T.
Warwick	.....	.....	.....	3.24	.....
Waverly†	82	18	46.9	3.10	0.2
Wedgwood	80	16	44.9	2.72	4.0
Westfield	79	22	45.1	2.99	4.0
Westpoint†	78	24	49.3	3.17	
Willetspoint	77	26	49.0	3.21	
North Carolina.					
Abshers	87	26	55.4	4.20	
Asheville†	83	29	54.2	3.81	
Beaufort†	78	38	61.2	3.53	
Biltmore†	83	28	54.4	4.78	
Bryson City†	.....	.....	.....	4.79	
Chapelhill†	88	31	58.4	3.31	
Edenton	83	31	57.8	0.98	
Experimental Farm	84	30	59.0	2.99	
Fairbluff†	.....	.....	.....	1.89	
Falkland	.....	.....	.....	2.77	
Fayetteville†	87	29	59.4	2.77	
Flatrock	80	27	52.8	8.22	
Greensboro†	91	31	59.4	3.38	
Henderson†	90	28	58.0	3.25	
Highlands	74	25	49.4	7.70	
Horse Cove†	74	24	49.2	8.80	
Jacksonville	89	30	62.0	1.47	
Lenoir*†	82	33	54.7	5.17	
Linville†	75	22	46.9	5.12	
Littleton†	88	25	56.3	3.23	
Louisburg†	88	27	58.9	4.30	
Lynn*†	86	.....	56.3	10.57	
Marion	87	30	57.3	6.74	
Moncure†	86	30	59.9	2.89	
Monroe†	84	29	59.0	4.81	
Morganton*†	78	30	52.6	4.99	
Mountairy†	84	26	54.6	3.45	
Mount Pleasant	85	30	59.3	4.05	
Murphy†	.....	.....	.....	5.43	
Newbern†	83	40	62.2	1.91	
Oakridge†	84	29	56.4	3.96	
Pantego*†	82	31	57.2	1.96	
Pittsboro†	85	27	56.0	3.70	
Rockingham†	89	35	61.3	2.67	
Roxboro†	87	25	57.0	1.92	
Salem†	87	28	57.6	4.19	
Salisbury†	88	31	59.6	2.40	
Saxon†	88	28	56.8	3.26	
Selma	89	30	59.2	4.45	
Settle	89	30	57.6	4.24	
Skyuka	78	38	53.4	.....	
Sloan†	87	33	60.7	2.39	
Soapstone Mount†	87	26	58.2	3.61	
Southern Pines *a*†	90	29	62.0	4.07	
Southern Pines *b*	89	31	61.8	3.42	
Southport†	77	36	61.7	1.82	
Springhope*[1]	85	29	57.3	2.90	
Tarboro	90	26	59.0	2.81	
Waynesville†	81	26	53.2	5.08	
Weldon†	87	27	57.8	3.10	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
North Carolina—Cont'd.	°	°	°	*Ins.*	*Ins.*
Willeyton	89	26	58.8	1.48	
North Dakota.					
Amenia	85	16	41.4	1.49	
Ashley†	81	12	40.8	2.06	2.5
Bordulac	72	15	41.5	T.	
Buxton	74	14	40.2	0.90	
Churchs Ferry	73	15	39.9	1.20	T.
Coalharbor†	82	21	40.4	1.90	8.0
Devils Lake†	72	14	38.6	1.10	T.
Dickinson†	82	20	41.8	1.93	3.6
Dunseith	.....	.....	.....	0.66	2.9
Falconer	83	15	42.4	0.32	2.5
Fargo†	83*	7	37.5*	0.80	
Forman†	89	10	44.4	1.39	T.
Fort Berthold†	71	16	40.0	0.70	2.0
Fort Yates†	83	18	43.1	3.25	5.5
Gallatin†	77	12	40.9	0.77	0.3
Glenullin	84	.....	.....	1.17	2.0
Grafton†[f]	65	12	36.4	0.40	T.
Grand Rapids†	84	15	41.1	0.83	0.6
Hamilton	70	13	38.6	0.73	0.4
Jamestown†	73[1]	15[1]	44.9[1]	0.62	
Langdon†	67	12	36.0	.....	.....
Larimore†	72	14	38.6	0.81	
Lisbon†	90	17	42.4	0.90	
McKinney	81	12	39.2	1.65	
Mayville	78	11	44.2	0.49	T.
Medora†	91	22	45.0	0.72	0.5
Milton†	68	9	37.3	.....	.....
Minnewaukon	74	14	40.8	0.83	
Minot†	85	14	41.5	1.18	0.2
Minto†	75	14	40.0	1.10	T.
Napoleon†	77	16	40.2	1.43	1.0
Oakdale†	82	18	42.4	1.60	7.0
Portal†	84	15	40.4	1.34	
Power†	93	15	42 9	T.	
St. John†	67	10	36.4	0.54	
Sheyenne	75	14	39.6	0.77	T.
Steele†	77	15	40.6	1.62	3.3
Towner†	79	16	40.6	.....	
University†	70	13	41.4	0.56	T.
Valley City†	78	16	39.0	0.76	.....
Wahpeton†	92	17	46.8	1.84	
White Earth	90	20	41.3	1.20	0.5
Wildrice†[2]	.....	.....	41.6	0.71	T.
Woodbridge†	69	8	38.0	0.04	
Ohio.					
Akron	79	33	48.0	1.66	0.2
Annapolis	83	21	49.0	4.28	T.
Ashland	81	22	47.2	2.75	3.0
Ashtabula	78	25	44.9	2.27	2.0
Atwater	.....	.....	.....	3.22	T.
Auburn	.....	.....	.....	2.23	.....
Bangorville	79	18	47.4	3.23	1.5
Bellefontaine	.....	.....	.....	1.92	0.5
Bement	.....	.....	.....	3.12	3.0
Benton Ridge	84	16	48.8	4.06	10.9
Bethany	85	25	53.3	3.78	
Bigprairie	81	21	48.4	3.05	.....
Binola	84	28	50.6	2.36	4.0
Bissells	79	21	43.7	2.52	8.7
Bowling Green	81	17	47.0	2.64	5.0
Bucyrus	84*	20*	49.6*	1.30	2.0
Cambridge	81	21	49.0	3.49	
Camp Dennison	82	27	53.0	3.64	T.
Canal Dover	82	22	48.3	4.05	
Canfield	.....	.....	.....	3.35	1.0
Canton†	81	23	49.0	3.59	
Cardington	80	19	46.5	3.09	1.5
Carrollton	81	20	48.9	3.38	
Cedarville	.....	.....	.....	4.30	.....
Celina	85	20	50.6	2.29	
Cherryfork	86	22	51.8	3.72	
Circleville	82	25	52.3	3.85	
Clarksville	81	23	51.0	3.98	T.
Cleveland *a*	76	26	46.9	2.32	4.7
Cleveland *b*	80	26	46.8	1.28	1.5
Clifton	82	20	49.6	4.14	1.5
Coalton	84	24	51.6	3.67	
Colebrook	78	21	46.6	2.41	
Dayton *a*	83	21	51.0	4.26	
Dayton *b*†	.....	.....	.....	3.27	
Defiance	80	18	47.4	2.68	3.1
Demos	81	24	49.3	2.74	.....
Dupont	79	18	47.5	2.16	3.0
Elyria	81	25	46.7	1.83	8.3
Fairport Harbor*[10]	80	29	46.9	.....	.....
Fayetteville	80	24	51.4	3.87	
Findlay	83	19	48.9	3.66	
Frankfort	83	23	51.0	3.84	
Garrettsville†	80	20	46.6	2.49	3.5
Granville	82	22	49.4	3.39	
Gratiot	80	23	49.6	2.94	T.
Greenfield	82	27	52.6	3.30	T.
Greenhill	82	20	47.6	2.53	6.2
Greenville	78	21	47.6	5.12	6.0

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Ohio—Cont'd.	°	°	°	*Ins.*	*Ins.*
Hackney	84	25	51.2	3.55	
Hanging Rock	86	28	52.2	4.60	
Hedges	79	17	47.5	4.11	10.2
Hillhouse	78	16	44.8	1.92	9.0
Hillsboro†	87	23	52.4	3.40	
Hiram	78	21	46.5	2.47	4.0
Hudson	78	22	45.7	2.14	.....
Jacksonboro	84	22	50.4	3.55	1.0
Kenton†	84	19	49.8	3.16	3.5
Killbuck	82	20	49.2	3.23	T.
Lancaster	82	24	50.4	3.05	
Leipsic	80	17	46.8	3.20	4.0
Levering	84	13	46.2	2.64	6.0
Logan	85	22	50.4	3.45	
Lordstown	78	23	47.4	2.74	0.5
McArthur	82	23	51.0	3.11	
McConnelsville†	83	24	52.2	3.51	
Mansfield†	.....	.....	.....	2.71	3.0
Marietta *a*†	.....	.....	.....	3.54	
Marietta *b*	83	21	51.4	3.77	
Marion	83	18	49.0	2.45	0.2
Medina	82	21	47.6	2.16	3.0
Milfordton	81	19	47.6	3.10	
Milligan	85	21	51.1	3.38	
Millport	78	21	46.8	3.18	.....
Montpelier	79	17	46.6	3.51	3.0
Napoleon	80	13	46.5	3.04	7.5
Neapolis	.....	.....	.....	2.74	3.5
New Alexandria	80	22	49.3	3.67	
New Berlin	82	20	47.5	2.45	T.
New Bremen	80	18	48.9	4.01	
New Comerstown	82	23	49.5	3.70	T.
New Holland	82	23	50.0	4.63	T.
New Moscow	.....	.....	.....	3.33	
New Paris	78	21	49.2	4.13	
New Waterford	.....	.....	.....	3.40	0.5
North Lewisburg	83	19	49.4	3.20	1.0
North Royalton	81	22	47.6	2.29	3.0
Norwalk	82	18	45.1	2.37	3.0
Oberlin	83	21	46.6	2.00	T.
Ohio State University	80	22	49.6	3.80	
Orangeville	81	20	46.6	2.08	T.
Ottawa	81	20	49.6	3.70	3.0
Pataskala†	82	20	49.6	3.58	0.3
Philo	83	21	50.4	3.19	
Plattsburg	82	21	49.1	3.25	T.
Pomeroy	84	27	52.5	3.32	
Portsmouth *a*†	.....	.....	.....	4.55	
Portsmouth *b*	92	28	55.4	4.75	
Richwood	.....	.....	.....	3.30	1.0
Ridgeville Corners	80	11	47.3	3.76	8.0
Ripley	81	26	52.6	5.54	
Rittman	80	18	45.2	1.44	
Rockyridge	83	19	47.0	2.72	T.
Rosewood	79	19	48.1	3.51	
Shenandoah	82	19	46.9	1.87	9.0
Sidney *b*	81	22	48.4	3.68	1.5
Sinking Spring†	80	25	52.3	4.11	
Springboro	.....	.....	.....	4.38	T.
Spring Valley	86	22	50.2	3.95	
Strongsville	.....	.....	.....	3.88	3.5
Sylvania	82	17	46.8	2.54	5.0
Thurman	88	25	54.0	3.02	
Tiffin†	80	21	48.0	2.96	2.0
Upper Sandusky	81	21	49.8	3.63	2.0
Urbana	78	21	48.7	2.75	
Vanceburg	85	20	52.6	2.67	
Van Wert	81	17	47.1	3.49	6.5
Vermilion	81	22	47.0	1.82	7.0
Vickery	83	23	48.2	2.42	2.6
Walnut	.....	.....	.....	3.07	T.
Warren	82	22	47.2	2.48	0.8
Wauseon	81	16	47.2	5.69	6.8
Waverly	86	25	53.0	4.79	T.
Waynesville	78	20	48.9	4.38	T.
Wellington	83	22	49.0	2.72	0.5
Westerville	80	23	50.2	4.12	T.
Willoughby	.....	.....	.....	1.71	
Wooster *a*	.....	.....	.....	2.64	T.
Wooster *b*†	79	21	47.4	2.75	1.0
Youngstown	88	23	47.2	2.68	T.
Oklahoma.					
Alva	88	43	57.2	3.40	
Anadarko†	87	32	61.7	3.32	
Arapaho†	87	31	58.6	4.22	
Beaver	.....	.....	.....	6.23	
Burnett†	83	34	59.9	4.41	
Clifton†	85	32	60.8	9.22	
Edmond	81	35	59.0	13.35	
Fort Reno†	82	32	59.2	7.36	
Fort Sill	84	34	60.4	0.80	
Hennessey	86	31	60.4	5.39	
Kingfisher†	84	31	60.6	6.04	
Mangum†	82	32	60.0	2.72	
Norman†	97	31	60.5	4.87	
Ponca	88	.....	.....	8.38	
Pondcreek†	89	28	61.0	5.80	
Prudence†	87	30	58.5	6.49	
Sac and Fox Agency†	83	32	59.0	7.90	
Stillwater†	83	32	58.3	6.36	
Waukomis	87	31	57.9	4.15	
Winnview†	84	33	58.1	4.49	
Woodward	88	30	57.7	1.08	
Oregon.					
Albany *a*	82	36	54.1	2.06	
Arlington	85	34	55.9	0.26	
Ashland *b*	89	29	53.0	0.99	
Aurora [8]	92	40	58.5	2.48	
Aurora (near)	88	29	52.9	2.03	
Bandon	79	33	49.7	0.86	
Bay City†	79	30	51.8	3.87	
Brownsville [8]	82	45	58.6	1.58	
Burns†	79	14	44.2	1.10	
Burns (near)	84	21	47.4	0.15	1.5
Canyon City	97	28	53.3	2.71	
Cascade Locks	86	38	54.6	4.04	
Comstock [8]	86	36	51.3	1.60	
Corvallis *a*	84	33	53.4	1.73	
Dayville†	92	26	51.5	0.94	
Eugene *a*†	80	34	52.6	1.27	
Falls City	.....	.....	.....	3.28	
Fife†	85	20	44.4	3.90	2.0
Forest Grove	93	32	53.9	2.04	
Fort Klamath	75	10	46.5	0.75	2.8
Gardiner	84	37	51.8	2.70	
Glenora	90	29	50.6	4.56	
Government Camp	74	18	41.0	5.50	36.5
Grants Pass *a*†	92	29	54.5	0.67	
Happy Valley	84	20	44.8	2.33	6.0
Hood River (near)	85	34	53.1	1.84	
Irvington	.....	.....	.....	1.82	
Jacksonville	85	29	53.1	1.02	
Joseph	75	21	43.8	0.58	5.2
Junction City [8]	84	38	53.0	1.20	
Lafayette [8]	90	35	54.0	1.84	
Lakeview†	77	19	46.2	1.03	0.5
Langlois	86	37	55.0	3.23	
McMinnville†	88	30	53.0	2.00	
Merlin [8]	92	30	52.5	0.72	
Monmouth [8]	84	39	57.2	1.98	
Mount Angel†	94	32	54.8	2.41	
Nehalem	.....	.....	.....	4.73	
Newberg	89	31	53.6	2.21	
Newport	79	35	50.6	2.09	
Pendleton	90	31	55.0	0.95	
Prineville	91	20	50.0	0.51	T.
Riddles [8]	88	35	53.7	0.49	
Salem *b*†	84	34	53.4	3.47	
Sheridan [8]	85	41	56.7	2.11	
Silver Lake	85	13	44.5	0.25	1.5
Silverton [8]	84	40	54.4	2.76	
Siskiyou [8]	78	33	52.8	0.00	
Sparta	75	20	44.9	0.97	9.0
Springfield [8]	90	38	52.9	1.85	
Stafford	89	29	52.8	3.42	
The Dalles†	88	34	55.8	0.23	
Tillamook Rock L. H.	.....	.....	.....	2.52	
Vale	86	26	50.2	0.66	
Vernonia	100	27	55.3	2.13	
West Fork [8]	94	32	51.5	1.44	
Weston	82	32	53.0	1.87	
Williams	87	28	52.6	0.87	
Pennsylvania.					
Altoona	83	23	51.6	2.91	
Aqueduct	90	26	52.3	2.53	T.
Beaver Dam	.....	.....	.....	3.88	T.
Bethlehem	.....	.....	.....	3.41	
Blooming Grove	80	12	45.6	4.10	T.
Brookville†	.....	.....	.....	1.85	
Browers Lock	.....	.....	.....	3.38	
Cameron	.....	.....	.....	2.70	
Canonsburg	83	27	51.2	1.99	T.
Carlisle	88	24	50.6	2.92	
Cassandra	77	30	46.4	3.56	T.
Cedarrun	.....	.....	.....	2.44	
Centerhall†	83	20	48.6	3.84	1.0
Chambersburg†	86	15	48.8	2.79	
Coatesville	87	24	51.2	3.39	
Confluence†	83	21	48.8	3.33	
Coopersburg	83	24	50.8	3.59	T.
Davis Island Dam†	.....	.....	.....	3.30	T.
Derry Station	84	21	49.2	3.81	T.
Doylestown	.....	.....	.....	3.80	
Drifton	81	17	48.1	3.55	3.0
Driftwood	.....	.....	.....	3.58	
Dubois	.....	.....	.....	3.45	
Duncannon	.....	.....	.....	2.59	
Dunmore	85	15	47.0	3.27	
Dushore	91	16	45.9	2.70	0.3
Dyberry†	83	18	45.2	3.72	
East Bloomsburg	.....	.....	.....	2.54	.....
East Mauch Chunk	87	21	50.0	3.29	1.0
Easton	82	22	50.1	1.20	T.
Edinboro [1]	72	18	43.5	.....	2.5
Ellwood Junction†	.....	.....	.....	3.82	
Emporium	80	22	47.2	3.49	T.
Farrandsville	.....	.....	.....	3.35	T.
Forks of Neshaminy [1]	80	30	52.0	2.93	T.
Franklin	81	22	47.9	3.22	
Frederick	.....	.....	.....	3.06	
Freeport†	.....	.....	.....	4.29	
Gettysburg	92	30	52.3	.....	
Girardville	.....	.....	.....	3.77	2.5
Grampian	80	20	46.0	4.14	2.0
Greensboro†	86	20	49.8	3.98	T.
Greenville	78	22	47.2	2.93	
Hallstead†	82	19	47.0	2.40	
Hamburg	88	25	52.0	3.76	
Hollidaysburg	85	21	50.6	2.77	
Honesdale	.....	.....	.....	3.95	
Huntingdon *a*†	86	23	50.2	3.86	
Huntingdon *b*	.....	.....	.....	3.55	
Indiana [1]	79	30	51.2	.....	
Irwin	.....	.....	.....	4.05	
Johnstown†	88	23	49.4	3.98	T.
Karthaus	.....	.....	.....	1.70	
Keating	.....	.....	.....	3.28	T.
Kennett Square	86	24	51.0	3.19	
Lancaster	85	24	49.8	.....	
Lansdale	.....	.....	.....	3.36	
Lawrenceville	81	19	47.6	2.90	
Lebanon	86	24	49.9	3.51	T.
Leroy†	84	15	44.8	2.70	0.7
Lewisburg	85	24	49.9	3.21	0.2
Lock Haven *a*†	90	24	51.8	3.42	
Lock Haven *b*	.....	.....	.....	2.90	0.5
Lock No. 4†	.....	.....	.....	3.33	
Lycippus	80	22	50.0	3.93	
Mifflin	.....	.....	.....	2.81	
Oil City†	.....	.....	.....	3.54	
Ottsville	.....	.....	.....	3.28	
Parker†	.....	.....	.....	3.42	
Philadelphia *b*	84	27	52.9	3.53	
Point Pleasant	.....	.....	.....	2.91	
Pottstown	89	26	52.9	3.80	
Quakertown	84	21	48.8	3.32	T.
Reading [2]	.....	.....	50.3	3.89	
Renovo *a*	.....	.....	.....	2.86	T.
Renovo *b*	85	23	49.4	2.64	
Ridgway†	.....	.....	.....	3.57	T.
Saegerstown	79	14	45.6	2.22	
St. Marys	76	19	45.2	2.93	
Salem Corners	81	17	46.7	3.78	T.
Scranton	85	20	48.4	3.41	
Seisholtzville	.....	.....	.....	3.53	
Selinsgrove	87	24	50.4	3.25	1.0
Shawmont	.....	.....	.....	2.84	
Shinglehouse	80	15	47.6	2.87	2.0
Sinnamahoning	.....	.....	.....	2.49	
Skippack	84	20	49.6	3.67	
Smethport	78	17	44.8	3.43	
Smiths Corners	.....	.....	.....	3.30	
Somerset	78	18	47.0	3.99	T.
South Bethlehem	85	24	50.2	.....	
South Eaton	84	21	48.1	3.11	
State College	83	24	48.0	3.78	3.0
Swarthmore	82	28	52.8	.....	
Swiftwater	82	20	46.6	2.67	
Towanda	83	21	48.0	2.30	T.
Uniontown	81	25	50.1	4.63	
Warren†	81	20	46.7	3.21	T.
Wellsboro†	82	20	45.6	2.55	T.
West Chester	83	25	51.0	3.06	
West Newton†	.....	.....	.....	3.60	
White Haven [4]	83	19	46.2	3.99	T.
Wilkesbarre†	87	22	51.1	3.34	T.
Williamsport	85	19	49.6	2.25	T.
York†	85	25	50.4	3.42	
Rhode Island.					
Bristol	66	23	46.0	4.03	T.
Kingston	71	22	45.6	4.81	T.
Providence *a*	78	24	50.0	3.30	T.
South Carolina.					
Allendale†	92	43	64.2	2.66	
Anderson†	.....	.....	.....	4.20	
Batesburg†	85	37	61.2	2.08	
Blackville†	90	41	58.1	2.94	
Camden†	.....	.....	.....	3.13	
Central†	88	36	59.0	.....	
Cheraw *a*†	94	34	61.6	2.17	
Cheraw *b*†	.....	.....	.....	2.54	
Conway†	.....	.....	.....	1.59	
Darlington (near)	.....	.....	.....	4.36	
Edisto†	.....	.....	.....	3.22	
Effingham†	.....	.....	.....	1.60	
Florence†	86	32	61.0	2.27	
Georgetown†	81	42	62.4	5.85	
Gillisonville†	95	36	65.6	1.41	

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
South Carolina—Cont'd.	°	°	°	*Ins.*	*Ins.*
Greenville†	82	36	58.2	4.82	
Greenwood	86	39	61.1	4.28	
Holland	87	32	58.8	4.62	
Kingstree *a*†	87	35	60.3	1.79	
Kingstree *b*†				1.79	
Little Mountain	89	37	62.8	2.76	
Longshore†	87	38	61.3	2.98	
Mount Carmel†				5.50	
Pinopolis *[1]	83	46	62.8	3.74	
Port Royal†	81	48	66.0	2.42	
St. George†	86	42	63.4	2.03	
St. Matthews†	87	41	62.8	1.81	
St. Stephens†				2.14	
Santuck†	85	32	60.0	4.11	
Shaws Fork *[1]	85	40	65.8	2.45	
Smiths Mills†				1.67	
Society Hill†	84	36	61.3	6.31	
Statesburg†	87	39	63.6	4.86	
Trenton	85	42	64.5	3.32	
Trial†	86	40	62.6	2.97	
Walhalla	85	31	57.9	8.40	
Winnsboro	85	35	60.3	2.82	
Yemassee†	90	42	64.8	2.15	
Yorkville	86	37	61.4	4.07	
South Dakota.					
Aberdeen†	91	19	43.5	3.39	
Alexandria†	85	18	45.6	3.59	T.
Armour†	84	22	47.0	4.65	
Ashcroft†	86	19	44.6	1.26	2.0
Brookings	83	16	44.1	2.45	
Canton	80	22	46.4	3.63	
Castlewood†	86	16	43.8	3.20	T.
Centerville				2.10	
Chamberlain†	87	23	47.2	3.53	
Clark				3.60	
Cross†	77	15	40.2	1.01	6.0
Doland	88	15	44.6	3.37	T.
Edgemont				0.80	
Farmingdale				0.60	T
Faulkton	89	22	42.8	4.23	5.2
Flandreau†	88	17	45.2	2.94	3.5
Forestburg†	86	23	46.2	3.92	
Forest City	75	22	38.4	2.40	4.0
Fort Meade†	82	10	44.8	1.80	7.0
Gary	86	17	44.0		3.0
Goudyville	90	17	43.6	2.16	6.5
Greenwood†	82	23	47.5	6.13	
Highmore	89	20	44.0	3.44	13.0
Hotch City†	88	20	46.2	2.89	2.0
Hot Springs	75	21	45.5	0.70	0.4
Howard†	84	21	44.5	3.53	T.
Kimball†	85	20	46.2	4.20	2.0
Leslie†	87	25	47.2	1.40	
Mellette†	91	16	45.2	2.51	1.1
Menno†	86	22	47.3	3.02	0.5
Millbank	87	18	44.4	2.15	
Mitchell†	85	22	46.0	4.79	
Oelrichs†	89	14	45.6	2.20	
Parker†	85	21	46.2	2.91	
Parkston	84	21	46.9	3.71	
Plankinton†	85	21	45.9	3.95	
Rosebud	83	18	42.2	2.87	
Shiloh	90	25	45.6	1.30	
Sioux Falls†	85	20	45.5	2.74	
Spearfish†	80	26	45.8	1.80	13.0
Tyndall†	86	22	47.2	4.84	
Vermillion	90	23	47.6		
Watertown	82	15	43.2	2.87	
Webster†	88	16	42.8	1.59	0.6
Wentworth†	83	19	44.8	2.78	2.0
Wessington Springs	85	18	45.0	4.18	1.5
Tennessee.					
Andersonville	84	31	58.1	7.47	
Arlington†	86	36	61.4	5.05	
Ashwood *† [1]	83	40	59.7	6.20	
Benton (near)†	84	30	58.0	4.39	
Bolivar†	84	32	59.2	6.65	
Bristol†	81	29	53.8	3.39	
Brownsville†	88	36	61.2	4.91	
Byrdstown	88	29	58.6	6.89	
Cagle	82	32	56.1	5.67	T.
Carthage†				8.45	
Charlotte	85	30	58.1	7.55	
Clarksville	83	34	57.6	8.09	
Clinton†				7.57	
Decatur†	85	31	57.8	8.55	
Dyersburg	82	34	59.1	6.43	
Elizabethton†	87	30	55.9	2.84	
Elk Valley	85	30	58.0	6.93	
Erasmus	84	25	54.0	7.96	
Fairmount *[1]	76*	34	55.2*	7.49	
Florence†	82	32	58.1	7.89	
Franklin	83	32	57.8	7.85	
Greeneville†	84	30	55.9	3.07	
Harriman	85	32	57.6	9.25	
Hickory Withe	82	36	61.2	4.82	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Tennessee—Cont'd.	°	°	°	*Ins.*	*Ins.*
Hohenwald †	86	26	57.2	6.22	
Jackson †	82	35	60.2	6.62	
Johnsonville†	82	33	59.5	5.69	
Jonesboro *† [1]	78	38	55.0	4.18	
Liberty†	84	30	58.0	6.32	
Loudon†				7.75	
Lynnville *† [1]	83	34	57.3	6.66	
McKenzie†	81	35	59.8	9.41	
McMinnville†	84	32	58.2	5.90	
Milan†	82	33	60.4	7.79	
Molino †	84	34	59.6	5.32	
New Market				3.66	
Newport †	81	31	56.9	4.10	
Nunnelly *[1]	83	37	59.2	5.75	
Oak Hill *[1]	84	31	56.4	7.55	
Palmetto†	84	34	58.6	7.12	
Pope	85	31	59.4	3.65	
Riddleton†	84	32	57.8	7.56	
Rockwood†				6.98	
Rogersville†	80	31	55.8	3.83	
Rugby	81	26	54.2	6.94	
St. Joseph†	88	29	59.7	6.61	
Savannah	86	33	60.8	4.58	
Sewanee†	76	32	56.0	5.96	
Springdale *[1]	88	30	57.6	5.66	
Springfield *[1]	81	36	58.1	7.08	
Tellico Plains†	83	30	58.6	5.64	
Trenton	81	34	58.8	6.10	
Tullahoma †	78	30	55.7	6.25	
Union City †	83	34	59.1	6.07	
Waynesboro	82	29	58.5	4.72	
Texas.					
Albany *[1]	76	35	59.5	1.35	
Arthur City†				2.38	
Austin *b* [5]	85	40	65.2		
Ballinger †	93	34	65.6	0.65	
Beeville †	92	46	71.3	0.53	
Blanco†	97	36	63.2	2.01	
Boerne *† [1]	86	42	65.9	3.26	
Bowie	84	36	62.2	2.36	
Brady	91	33*	63.3	1.31	
Brazoria†	85	47	68.3	2.25	
Bremond *[1]	85	47	67.3	3.04	
Brenham †	88	44	68.9	1.98	
Brighton †	87	44	69.6	0.82	
Brownwood	91	32	65.4	2.15	
Burnet *[1]	84	42	66.5	2.60	
Camp Eagle Pass †	101	52	74.8	1.01	
Childress *[1]	87	32	59.0	1.66	
Coleman *[3]		37	61.0	1.05	
College Station	89	43	66.8	1.57	
Columbia†	89	45	67.9	2.33	
Corsicana *b* †	87	50	70.5	1.90	
Cuero†	89	45	68.0	2.85	
Dallas†	86	39	63.3	2.58	
Danevang†	88	44	68.2	2.81	
Dean	86	28	55.6		
Dublin†	86	39	62.8	3.23	
Duval *[1]	90	46	70.2	3.19	
Estelle†	86	34	63.4	2.02	
Forestburg†	82	38	64.2	2.02	
Fort Clark	97	38	68.2	1.94	
Fort McIntosh	95	45	72.2	0.15	
Fort Ringgold†	96	45	73.6	1.88	
Fort Worth†	85[4]	39[4]	65.8[4]	3.32	
Fredericksburg *† [1]	87[1]	37	65.2[1]	3.00	
Gainesville†	82	38	62.8	2.90	
Georgetown *[1]	85*	38*	62.8*	2.42	
Golindo				2.50	
Graham †	90	33	62.3	2.03	
Grapevine†	84	38	64.2	3.37	
Hale Center†	86	34	60.6	1.65	
Hallettsville†	89	45	69.2	4.57	
Hewitt				2.75	
Houston†	89	47	68.6	0.83	
Huntsville†	86	43	67.1	1.73	
Junction City	89	32*	65.8*	0.94	
Kent				0.06	
Kerrville†	89	30	63.7	1.38	
Lampasas†	88	36	65.2	1.88	
Llano *† [5]	90	42	66.8	1.42	
Longview†	86	41	65.8	4.61	
Luling†	88	45	69.2	5.70	
Marathon	90	31	61.7	1.00	
Marshall	85	50	68.2	3.51	
Midland	96	28	63.2	0.00	
Mount Blanco†	87	29	59.4	0.05	T.
New Braunfels†	88	45	67.4	3.10	
Orange†	81	44	66.0	0.50	
Panter †				2.34	
Paris †	84	32	62.8	2.68	
Point Isabel *[1]	88	60	73.4	1.75	
Rheinland †	83	35	62.0	1.38	
Roby †	88	31	60.1	1.75	
Rocksprings				1.70	
San Antonio	93	44	71.7	2.07	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Texas—Cont'd.	°	°	°	*Ins.*	*Ins.*
Sanderson†	94	30	64.4	1.30	
San Marcos *b*†	87	34	65.8	2.47	
Sierra Blanca †	89	27	61.0	T.	
Stafford †	89	42	67.2	1.67	
Sulphur Springs†	88	38	66.4	4.12	
Temple *a*	88	40	66.0	2.27	
Tivoli	91	46	66.0	0.06	
Tulia	83	25	55.0	1.08	
Tyler	85	40	65.2	3.57	
Valentine†	92	26	61.1	0.00	
Waco†	85	43	67.6	1.87	
Weatherford†	87	40	63.4	3.43	
Wichita Falls †				1.63	
Utah.					
Alpine City †				1.03	
Blue Creek *[2]	99	23	48.5		
Brigham City †				2.09	
Cisco†	83	28	53.8	1.46	1.0
Corinne	78	21	47.4	0.34	
Croyden	79			1.50	
Farmington				1.86	3.0
Fillmore †	89	16	50.6	1.36	
Fort Duchesne†	78	22	46.2	0.01	0.1
Frisco	79	23	48.4	T.	T.
Giles†	87	18	51.3	1.57	
Heber	80	18	43.0	0.90	2.0
Kelton *[2]	80	30	49.9		
Koosharem	72	6	40.2	0.75	1.0
Levan †	82	18	47.2	1.05	
Loa †	77	13	40.5	1.05	5.0
Logan†	74	19	44.0	1.74	
Mammoth †	75	21	44.9	0.14	1.5
Manti †	88	14	48.4	0.10	1.0
Minersville	81	21	48.8	0.16	1.0
Moab †	88	27	56.0	0.72	T.
Mount Pleasant †	87	22	49.0	0.10	1.0
Ogden *a* [2]	77	34	52.0	1.70	
Ogden *b*	79	24	50.1	1.47	6.8
Pahreah	87	26	53.7	3.25	
Park City†	66	14	39.0	1.50	15.0
Parowan†	81	18	48.2	0.95	2.5
Pinto				0.78	
Promontory *[2]	78	30	49.9	0.70	1.5
Richfield †	82	20	46.4	0.12	
St. George†	93	21	56.1	0.08	
Scipio †	81	19	46.8	1.26	6.0
Snowville	76	25	45.6	0.90	
Soldier Summit †	75	9	38.0	0.67	6.8
Terrace *[2]	74	23	46.5	0.50	
Thistle †	78	25	45.4		
Tooele †	78	27	49.0	0.91	
Tropic	74	18	45.2		
Vernal	73	22	48.0	0.58	
Woodruff	63	14	35.4	0.20	2.0
Vermont.					
Bennington	85	16	45.5	3.22	
Brattleboro	80	18	47.5	2.31	
Burlington †	76	16	45.7	4.01	T.
Chelsea †	78	7	40.2	2.91	10.0
Cornwall	82	12	44.8	3.50	T.
Enosburg Falls	80	13	43.2	3.91	0.5
Hartland †	82	15	43.4	3.25	6.0
Jacksonville	79	12	40.6	3.33	0.5
St. Johnsbury	81	12	43.0	2.84	T.
Strafford *† [1]	67	14	42.2	3.05	13.0
Vernon *[6]	79	30	47.4	2.68	
Wells	80	12	42.8	3.19	1.0
Woodstock	85	13	44.4	3.63	5.0
Virginia.					
Alexandria	86	28	53.7	2.68	
Ashland †	90	28	56.9	2.82	
Barboursville	88	29	53.4	2.06	
Bedford City	88	25	55.0	1.50	
Bigstone Gap †	85	24	52.9	4.61	
Birdsnest *† [1]	79	36	55.7	1.65	
Blacksburg	80	24	50.9	1.69	
Buckingham †	89	25	54.6	2.95	
Burkes Garden	78	24	49.8	1.97	
Callaville †	87	26	56.1	2.05	
Christiansburg †				1.76	
Clarksville †				2.85	
Clifton Forge	88	37	52.4	1.13	
Danville †				2.23	
Dale Enterprise †	84	22	50.8	1.70	
Doswell	81	24	58.7	1.90	
Farmville	95	28	55.8	1.01	
Fredericksburg †	87	29	55.3	2.31	
Gordonsville	77	32	53.8		
Goshen				2.00	
Grahams Forge	82	28	52.2	1.47	
Guinea	90	31	55.0	4.90	
Hampton	84	35	56.4	3.11	
Hot Springs	76	23	49.7	1.21	
Leesburg	94	25	51.6	2.23	
Lexington †	85	27	53.3	1.58	
Maidens				2.08	

TABLE II.—*Meteorological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Virginia—Cont'd.	°	°	°	*Ins.*	*Ins.*
Manassas†	90	28	54.0	2.09	
Marion†	83[c]	28[c]	54.2[c]	1.57	
Monterey	78	18	46.6	1.65	
Petersburg†	90	28	58.6	2.52	
Quantico	88	22	50.0	.....	
Radford†	.....	.....	.....	1.54	
Richmond (near)†	95	30	58.3	2.62	
Rockymount†	86	30	57.6	2.34	
Salem†	86	32	57.0	1.56	
Saltville	84	27	53.4	2.14	
Smithville†	85	31	56.3	1.70	
Spottsville†	90	26	56.1	2.06	
Stanardsville†	89	26	52.5	1.86	
Stanleyton	92	27	53.8	1.98	
Staunton†	88	26	53.4	1.56	
Stephens City†	88	25	52.7	2.30	
Sunbeam†	79	28	52.7	3.86	
Swords Creek	85	28	54.2	1.28	
Warrenton	86	31	55.2	2.06	
Warsaw†	88	27	54.7	1.71	
Westbrook Farm	90	30	55.0	.....	
Woodstock†	88	24	56.5	2.30	
Wytheville	82	29	51.6	1.72	
Washington.					
Aberdeen	81	34	50.7	3.40	
Anacortes	.....	.....	.....	1.24	
Ashford†	.....	.....	.....	3.24	
Blaine†	73	25	46.7	2.74	
Bridgeport	87	30	55.8	0.25	
Cascade Tunnel	63	18	39.3	1.05	14.0
Centerville†	81	28	52.0	0.38	
Chehalis†	94	29	54.0	1.54	
Colfax†	83	30	49.3	1.64	
Coupeville†	72	35	49.4	0.88	
Dayton	83	32	52.4	1.60	
Eastsound	71	36	50.0	1.37	
Ellensburg†	84	23	52.0	0.08	
Ellensburg (near)	84	30	52.6	0.10	
Elma	81	31	53.5	1.98	
Fort Simcoe†	90	30	56.6	0.00	
Fort Spokane	84	30	50.8	0.59	
Grandmound†	87	26	51.4	2.42	
Hunters†	74	23	43.4	1.16	
Kennewick†	86	30	54.4	0.11	
La Center	89	34	53.0	2.48	
Lakeside	78	33	52.8	0.54	
Lapush†	75	34	48.7	5.59	
Loomis†[d]	82	34	54.6	0.69	
Madrone*†[1]	79	32	51.4	1.25	
Mayfield†	88	31	51.7	.....	
Moxee Valley†	87	24	54.6	0.03	
New Whatcom†	77	32	51.5	1.33	
Northbend	84	31	53.4	5.40	
Olga	72	34	49.4	1.65	
Olympia†	83	30	51.8	1.28	
Pinehill†	85	30	52.4	0.50	
Pomeroy†	88	36	54.6	0.91	2.0
Pullman†	81	30	48.1	1.22	
Rosalia†	77	28	47.9	1.24	0.3
Sedro†	84	32	52.8	1.99	
Silvercreek*[1]	82	31	50.4	2.29	
Snohomish†	85	33	52.4	1.95	
Southbend	86	29	53.1	3.61	
Stillaguamish	80	29	49.6	2.08	
Sunnyside†	87	24	55.3	T.	
Tacoma†	84	34	50.7	1.64	
Union City†	87[b]	32[b]	52.8[b]	2.25	
Vashon†	81	34	50.6	1.59	
Waterville†	78	27	47.5	0.50	
Wenatchee Lake	82	24	45.4	.....	
West Ferndale	80	30	48.6	2.04	
West Virginia.					
Beverly†	86	22	51.5	2.79	T.
Bloomery†	84	21	47.1	1.64	
Bluefield†	88	27	53.4	1.58	
Buckhannon *a*†	.....	.....	.....	3.37	
Buckhannon *b*	83	23	50.0	.....	
Burlington†	85	21	50.6	2.03	
Charleston†	.....	.....	.....	2.84	
Clay	88	27	55.6	.....	
Dayton†	.....	.....	.....	3.22	
Elkhorn†	83	30	54.6	1.85	
Fairmont†	.....	.....	.....	3.42	
Glenville†	82	25	50.9	3.36	
Grafton†	85	23	50.4	3.10	T.
Green Sulphur	84	29	52.0	1.76	
Harpers Ferry†	.....	.....	.....	2.14	
Hewett†	90	28	56.9	2.84	
Hinton *a*†	.....	.....	.....	2.03	.....
Hinton *b*†	86	28	53.6	.....	T.
Huntington	82	29	54.4	3.70	
Kingwood	80	21	49.7	3.89	T.
Marlinton*††	79	21	47.6	2.85	T.
Martinsburg†	89	26	50.6	2.20	
Morgantown *a*†	.....	.....	.....	3.36	
Morgantown *b*†	85	24	51.5	3.80	
West Virginia—Cont'd.	°	°	°	*Ins.*	*Ins.*
New Martinsville†	84	26	53.0	3.79	
Nuttallburg†	84	22	51.0	2.00	T.
Oldfields†	86	23	52.2	1.91	
Pennsboro	84	26	51.9	3.40	T.
Philippi†	87	28	51.0	7.10	
Point Pleasant†	88	28	53.8	3.77	
Powellton [e]	85	30	55.4	.....	
Romney	82	28	52.4	1.70	
Rowlesburg†	.....	.....	.....	4.07	
Tannery*[1]	78	25	48.2	.....	
Weston *a*†	.....	.....	.....	3.28	
Wheeling *a*†	.....	.....	.....	3.95	T.
Wheeling *b*†	84	26	53.5	4.31	.....
White Sulphur Springs†	82	19	50.5	1.77	
Wisconsin.					
Amherst	74	17	44.0	2.24	T.
Antigo	78	11	40.6	1.71	7.0
Barron	76	12	42.9	1.86	9.0
Bayfield	73	17	40.0	1.05	.....
Beloit	74	23	46.3	4.72	
Chilton	74	17	43.9	2.98	1.0
Citypoint	75	.....	44.6	1.90	1.0
Crandon†	78	10	40.6	0.81	3.8
Delavan	75	22	45.7	4.87	T.
Dodgeville†	74	18	45.2	3.70	
Easton†	75	15	44.4	2.86	
Eau Claire [1]	75[e]	18	46.0	1.16	
Fond du Lac	76	20	44.7	2.61	2.0
Grand River Lock	.....	.....	.....	2.81	
Grantsburg†	76	17	44.2	0.75	
Hartford	.....	.....	.....	4.17	4.0
Hartland	75	20	44.0	4.89	
Harvey	73	21	45.2	3.71	0.1
Hayward†	77	15	42.3	0.31	0.5
Hillsboro	76	18	44.2	2.18	T.
Hudson	78[c]	21[c]	47.6[c]	1.59	
Koepenick*†[1]	66	20	41.1	0.80	4.0
Lancaster†	75	21	45.4	4.19	0.2
Lincoln†[2]	.....	.....	43.3	3.41	3.0
Madison†	73	22	45.0	2.51	T.
Manitowoc†	74	18	41.4	3.46	2.0
Meadow Valley†	76	18	45.2	1.75	
Medford†	76	11	41.2	1.34	0.2
Menasha	.....	.....	.....	0.50	0.8
Neillsville†	72	16	43.5	2.61	.....
New Holstein	71	18	43.0	4.30	4.0
New London	78	17	47.0	2.36	T.
Oconto	76	16	42.4	2.80	1.0
Osceola†	87	15	44.6	1.34	T.
Oshkosh†	74	18	44.3	2.52	0.8
Pepin	74	18	43.0	1.40	1.0
Pine River†	78	17	44.6	2.04	0.1
Portage†	77	18	44.8	2.49	T.
Port Washington	77	18	42.2	3.92	3.0
Prairie du Chien	79	25	50.4	2.44	.....
Racine	77	23	44.6	3.96	2.8
Sharon†	80	17	43.4	4.49	1.0
Shawano	76	15	42.4	2.42	1.0
Spooner†	82	10	42.8	0.10	
Stevens Point†	75	16	44.2	2.12	.....
Sturgeon Bay Canal*[10]	62	16	38.0	.....	.....
Valley Junction†	76	17	44.7	1.75	T.
Viroqua	72	19	45.0	2.73	T.
Watertown†	73	20	45.1	4.34	1.0
Waukesha†	76	21	44.6	4.10	3.3
Waupaca†	77	16	44.4	2.27	
Wausau†	74	15	42.8	1.91	0.2
Wausaukee	78	12	40.0	3.40	
Westbend	74	20	43.1	4.54	3.0
Westfield†	74	19	44.6	2.39	
Whitehall	75	16	44.3	2.06	0.5
White Mound†	78	18	46.2	3.14	0.5
Wyoming.					
Big Horn Ranch	72	2	37.3	0.51	0.8
Carbon	86	9	40.9	0.74	7.0
Fort Laramie†	84	19	44.6	1.03	8.0
Fort Washakie†	76	8	41.9	1.00	10.0
Fort Yellowstone†	66	11	37.9	1.21	7.8
Green River	77	17	43.8	0.50	1.0
Laramie	67	5	35.0	0.55	4.8
Lusk†	79	15	40.8	1.01	6.0
Sheridan	82	8	43.0	1.25	7.5
Sundance	75	15	39.9	1.67	9.0
Wheatland	80	10	45.7	0.62	0.5
Mexico.					
Ciudad P. Diaz	95	48	73.4	1.26	
Leon de Aldamas	90	49	69.8	0.02	
Mexico	86	46	66.0	1.23	
New Brunswick.					
St. John	60	18	38.4	3.72	7.3
West Indies.					
Grand Turk Island	.....	.....	.....	3.41	
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Alaska.					
Coal Harbor	50	— 11	26.2	2.88	13.0
California.					
Lick Observatory	53	19	32.8	6.45	30.5
Napa *b*	69	28	47.2	5.88	
Point Lobos	57	38	47.9	4.91	
San Jacinto	77	27	49.7	2.24	
San Miguel Island	71	37	50.8	1.63	
Engineers Quarters‡	.....	.....	.....	10.17	17.5
Morses House‡	.....	.....	.....	15.61	21.5
Deep Creek‡	.....	.....	.....	7.59	11.0
Holcomb Creek‡	.....	.....	.....	3.42	2.0
Squirrel Inn‡	.....	.....	.....	12.17	15.0
Colorado.					
Boxelder	.....	.....	.....	2.75	37.0
Connecticut.					
Wallingford	.....	.....	.....	3.84	.....
Kansas.					
Macksville	.....	.....	44.9	0.76	.....
McPherson	80	10	44.4	1.90	4.5
Russell	80	6	41.9	1.39	2.5
Montana.					
Glasgow	48	— 45	7.7	2.50	25.0
Lewistown	62	— 26	24.4	1.15	8.0
Nebraska.					
Benkelman	.....	.....	.....	1.18	.....
Nemaha	.....	.....	.....	1.62	.....
New Hampshire.					
Peterboro	55	— 21	30.3	3.33	8.0
New York.					
Garrattsville	72	0	31.9	2.38	4.2
Ohio.					
Wellington	.....	.....	.....	3.82	6.0
Oregon.					
Tillamook Rock L. H.	.....	.....	.....	7.83	.....
Texas.					
San Antonio	92	35	68.2	1.81	
Utah.					
Snowville	54	5	29.1	0.84	7.0
Virginia.					
Quantico	82	21	46.2	.....	
Mexico.					
Topolobampo*[1]	87	59	69.5	0.14	

EXPLANATION OF SIGNS.

* Extremes of temperature from observed readings of dry thermometer.

† Weather Bureau instruments.

‡ Record furnished by the Arrowhead Reservoir Company, in the San Bernardino Mountains, San Bernardino County, Cal., at elevations varying from 5,150 to 5,350 feet.

No note is made of breaks in the continuity of temperature records when the same do not exceed two days. All known breaks, of whatever duration, in the precipitation record receive appropriate notice.

CORRECTIONS.

Maine, Lewiston, March, 1897, make precipitation read 4.49 instead of 4.19.

Louisiana, Oakridge, February, 1897, make precipitation read 3.81 instead of 3.78.

California, Indio, December, 1896, make mean temperature read 55.0 instead of 45.0.

Nevada, Carson City, December, 1896, make mean temperature read 38.0 instead of 58.0.

New Hampshire, Keene, December, 1896, make minimum temperature read —9 instead of —0.

New Jersey, Asbury Park, December, 1896, make mean temperature read 29.1 instead of 30.1; New Brunswick *a*, December, 1896, make mean temperature read 31.7 instead of 51.7; Rivervale, December, 1896, make precipitation read 2.70 instead of 3.70.

New Mexico, Fort Union, December, 1896, make precipitation read 0.08 instead of 0.88.

New York, Canton, December, 1896, make mean temperature read 19.8 instead of 11.8.

Arizona, Farleys Camp, November, 1896, make precipitation read 2.60 instead of 0.60.

Pennsylvania, Bethlehem, November, 1896, make precipitation read 4.32 instead of 2.34.

New York, Ogdensburg, November, 1896, make precipitation read 3.01 instead of 2.58.

Arizona, San Carlos, October, 1896, make mean temperature read 64.9 instead of 44.9.

Oregon, Toledo, June, 1896, transfer all data to May, 1896, REVIEW.

NOTE.—The following changes have been made in names of stations:

Arizona, Eagle Pass, changed to Cedar Springs.

Nebraska, Bratton, changed to Eden.

TABLE III.—*Data from Canadian stations for the month of April, 1897.*

Stations.	Pressure.			Temperature.		Precipitation.		Prevailing direction of wind.	Total depth of snow.
	Mean not reduced.	Mean reduced.	Departure from normal.	Mean.	Departure from normal.	Total.	Departure from normal.		
	Inches.	*Inches.*	*Inches.*	°	°	*Inches*	*Inches.*		
St. Johns, N. F	29.79	29.94	+ .06	36.2	0.0	3.58	.....	s.	T.
Sydney, C. B. I	29.95	30.01	+ .14	37.8	+ 3.3	3.58	— 0.22	sw.	9.0
Grindstone, G. St. L.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Halifax, N. S	29.98	30.06	+ .16	40.3	+ 2.8	6.21	+ 2.90	w.	7.7
Grand Manan, N. B.	29.97	30.02	+ .04	38.8	.....	4.04	+ 0.64	w.	2.7
Yarmouth, N. S.	29.96	30.04	+ .13	40.2	+ 1.2	7.12	+ 4.18	sw.	6.6
St. Andrews, N. B.	.....	.....	.....	39.0	+ 0.7	2.65	+ 0.09	nw.	7.0
Charlottet'n, P. E. I.	29.96	30.00	+ .04	37.5	+ 2.6	3.32	+ 0.40	sw.	5.4
Chatham, N. B	29.98	30.00	+ .08	36.3	+ 2.8	2.98	— 0.12	w.	3.4
Father Point, Que.	29.96	29.99	+ .08	32.8	+ 0.3	3.28	+ 1.26	e.	0.5
Quebec, Que	29.68	30.02	+ .07	35.9	+ 1.4	3.68	+ 1.29	ne.	0.7
Montreal, Que	29.81	30.02	+ .06	41.1	+ 2.6	3.27	+ 0.83	sw.	1.9
Rockliffe, Ont	29.51	30.03	+ .07	37.4	+ 3.4	4.09	+ 2.85	nw.	4.1
Kingston, Ont	29.74	30.06	+ .09	40.8	+ 2.3	2.22	+ 0.27	sw.	0.8
Toronto, Ont	29.68	30.07	+ .08	42.0	+ 2.0	2.53	+ 0.65	s.	4.1
White River, Ont	28.71	30.10	+ .04	30.1	— 1.0	0.98	+ 0.06	ne.	2.5
Port Stanley, Ont	29.42	30.07	+ .06	41.4	.....	3.02	+ 0.89	s.	4.2
Saugeen, Ont	29.34	30.07	+ .07	37.9	+ 2.7	2.56	+ 0.73	sw.	1.7
Parry Sound, Ont	29.34	30.05	+ .07	38.2	+ 3.7	3.88	+ 2.16	s.	0.3
Port Arthur, Ont	29.32	30.04	+ .02	35.0	+ 2.5	0.64	— 0.73	ne.	0.0
Winnipeg, Man	29.16	30.00	— .03	37.8	+ 4.3	1.01	— 0.34	n.	0.5
Minnedosa, Man	28.19	30.03	+ .05	36.7	+ 3.2	0.87	— 0.25	e.	0.4
Qu'Appelle, Assin.	27.72	30.01	+ .05	38.4	+ 2.9	0.39	— 0.67	nw.	2.7
Medicine Hat, Assin	27.67	29.98	+ .06	45.8	+ 1.8	0.39	— 0.12	w.	0.2
Swift Curr't, Assin.	27.39	29.99	— .01	41.3	+ 2.8	0.08	— 1.10	nw.	T.
Calgary, Alberta	26.49	30.05	+ .13	41.6	+ 3.6	0.31	— 0.31	w.	0.7
Prince Albert, Sask.	28.36	29.89	.....	40.8	.....	0.70	.....	s.	5.8
Edmonton, Alberta.	27.63	29.99	+ .08	41.6	+ 1.4	0.46	— 0.11	nw.	0.0
Battleford, Sask	28.24	29.98	.....	41.1	.....	0.30	.....	w.	0.6
Kamloops, B. C.	28.82	30.05	.....	51.1	.....	0.05	.....	w.	0.0
Hamilton, Bermuda	30.00	30.16	+ .11	65.0	.....	5.22	.....	s.	.....
Banff, Alberta	25.33	30.01	... .	38.3	.....	1.07	.....	sw.	0.6
Esquimalt, B. C.	30.12	30.15	... .	46.6	.....	1.04	....	sw.	0.0
Ottawa, Ont	29.70	30.07	.....	40.8	... .	1.82	.....	nw.	....
Sable Island, N. S.	30.03	30.06	.....	39.6	.....	5.63	.....	sw.	0.2

TABLE IV.—*Meteorological observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, Meteorologist to the Government Survey.*

Pressure is corrected for temperature and reduced to sea level, but the gravity correction, —0.06, is still to be applied.

The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 10. Two directions of wind, connected by a dash, indicate change from one to the other; also same for force.

The rainfall for twenty-four hours is given as measured at 6 a. m. on the respective dates.

March, 1897.	Pressure at sea level.			Temperature.					Relative humidity.			Wind.		Cloudiness.	Rain measured at 6 a. m.
	9 a. m.	3 p. m.	9 p. m.	6 a. m.	2 p. m.	9 p. m.	Maximum.	Minimum.	6 a. m.	2 p. m.	9 p. m.	Direction.	Force.		
	Ins.	*Ins.*	*Ins.*	°	°	°	°	°	%	%	%				*Ins.*
1	30.10	29.99	30.10	64	78	68	80	63	79	56	80	se-n.	1	3	0.00
2	30.08	29.99	30.09	67	79	69	81	65	80	64	79	se-s.	2	4	0.00
3	30.06	30.00	30.09	68	78	71	80	67	81	65	86	sw-s.	2	3	0.03
4	30.09	30.00	30.09	69	76	69	79	68	70	78	81	nw-sse.	0-3	8	0.03
5	30.09	30.01	30.12	68	79	72	80	66	81	60	75	sw-nne.	3	6	0.04
6	30.06	30.00	30.10	71	78	70	79	70	72	60	81	e.	3	7	0.00
7	30.09	30.02	30.09	69	77	71	81	66	83	71	86	s-e.	2	3-9	0.00
8	30.07	30.03	30.14	70	78	69	79	69	77	67	88	ne-se.	3	5	0.25
9	30.14	30.05	30.14	70	79	71	78	69	70	52	68	ene.	4	3	0.08
10	30.13	30.07	30.16	70	80	71	80	70	70	54	68	ene.	4	3	T.
11	30.18	30.08	30.16	69	79	70	78	69	81	43	68	ene-nne.	4	3	0.01
12	30.12	30.04	30.13	68	77	68	79	67	76	55	68	ne.	4	6-10	0.11
13	30.13	30.04	30.12	68	77	70	77	67	81	59	68	ene.	3	5	0.37
14	30.10	30.00	30.09	66	77	68	77	66	95	59	85	e-nne.	1-4	7	0.27
15	30.09	30.02	30.12	71	78	71	78	69	72	63	70	ne.	4	8	0.22
16	30.12	30.05	30.13	70	78	71	79	70	64	54	70	ene.	4	4	0.03
17	30.13	30.07	30.14	70	78	70	79	70	74	61	77	ene.	4	4	T.
18	30.14	30.08	30.14	70	78	71	78	67	72	53	68	ne-nne.	4	3	0.05
19	30.15	30.07	30.16	66	79	68	80	65	75	53	85	ne.	3	3	0.00
20	30.18	30.09	30.20	67	79	71	79	65	85	55	72	e.	3	3-8	0.00
21	30.22	30.14	30.22	69	78	70	80	69	76	53	76	ne.	3	3	0.05
22	30.22	30.12	30.23	70	78	69	79	70	68	56	68	ene-n.	3	4	0.01
23	30.25	30.17	30.27	69	79	71	80	67	72	55	68	nne-n.	3	3	0.01
24	30.30	30.22	30.29	69	78	71	78	68	72	51	72	ene.	4	9-4	0.15
25	30.32	30.23	30.28	69	78	70	78	66	74	50	76	ene.	2-5	5	0.09
26	30.31	30.22	30.27	70	78	71	78	70	74	52	68	ene.	4-5	4	0.02
27	30.28	30.20	30.25	71	80	72	79	70	70	48	68	ene.	4	4	0.00
28	30.26	30.16	30.21	71	78	72	79	70	72	64	69	ene.	4-2	4-9	0.01
29	30.22	30.10	30.18	71	78	70	79	70	72	62	72	ne.	4-1	9-2	T.
30	30.20	30.11	30.20	68	79	71	79	67	76	66	69	ne-ene.	3	5	0.01
31	30.18	30.10	30.18	69	79	71	79	67	78	55	72	ene-ne.	4	3	0.03
	30.16	30.08	30.16	68.9	78.2	70.2	79.0	67.8	75.5	57.9	74.2	ene.	3.2	4.7	1.87

Mean temperature: 6+2+9+3 is 72.4; extreme temperatures, 81° and 63°.

A few rumblings of thunder on the 14th. On the same date there was a severe thunderstorm on Kauai.

Wind on 25th and 26th, a half gale throughout the group.

Temperature and barometer pressure above normal. Rains scanty, except at some windward stations. Four miles from Honolulu there was 7.33 inches of rain, at an elevation of about 1,000 feet above sea level. At Waikiki, 2 miles from town, only 0.32 inch at sea level.

Solar halo at midday March 5. Lunar rainbow (faint) March 17. Rainbows noted on fifteen days; one on the 21st on a background of apparently clear, blue sky.

TABLE V.—*Mean temperature for each hour of seventy-fifth meridian time, April, 1897.*

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Bismarck, N. Dak.	38.5	37.4	36.4	35.8	35.2	34.7	34.3	35.1	36.2	38.9	41.3	43.9	45.9	47.7	48.6	49.4	49.5	49.7	49.3	48.0	45.6	43.1	41.2	39.8	41.9
Boston, Mass.	43.9	43.7	43.3	42.8	42.5	42.4	43.5	46.0	48.4	50.5	52.8	53.5	53.5	54.1	54.3	54.2	53.3	52.7	51.0	49.2	48.2	47.1	46.1	45.4	48.4
Buffalo N Y.	41.1	40.9	41.2	40.0	39.4	39.1	40.5	41.4	42.6	43.8	45.4	46.0	46.8	47.0	47.8	47.3	46.4	45.5	44.4	44.6	43.4	42.9	42.9	42.6	43.5
Chicago, Ill.	43.3	43.0	42.7	42.4	42.0	41.6	41.4	42.4	43.4	43.9	44.6	45.4	45.7	46.0	47.1	47.7	48.1	47.7	47.4	46.6	46.1	45.8	44.8	43.7	44.7
Cincinnati, Ohio	50.1	49.3	48.7	48.1	47.8	47.1	47.2	48.2	49.2	51.2	53.0	54.8	56.1	57.4	57.9	58.4	58.6	58.3	57.1	56.1	54.7	53.4	52.1	50.9	52.7
Cleveland, Ohio	44.6	44.3	43.9	43.5	43.1	42.6	42.6	43.4	45.5	46.8	48.0	47.3	48.0	47.6	48.1	48.6	49.2	49.3	48.7	47.9	46.9	46.1	45.5	45.1	46.1
Detroit, Mich.	42.3	41.6	41.1	40.3	39.9	39.6	39.7	41.5	42.9	45.0	46.4	47.8	48.5	49.4	50.2	50.4	50.3	49.3	48.0	46.9	45.1	44.3	43.8	43.0	44.9
Dodge City, Kans.	47.7	47.3	45.9	45.3	44.5	43.6	42.9	43.3	46.3	49.6	53.6	56.9	59.5	61.3	62.8	64.0	64.3	64.3	62.7	60.2	56.0	53.4	51.3	49.5	53.2
Eastport, Me.	35.7	35.1	34.8	34.6	34.2	34.5	35.5	37.0	38.4	39.5	40.9	41.6	42.4	42.7	42.5	42.4	41.7	40.9	39.3	38.6	37.8	37.5	36.8	36.3	38.3
Galveston, Tex.	68.1	67.9	67.5	67.2	66.9	66.7	66.0	66.4	66.8	67.9	69.2	70.5	71.7	72.5	72.8	72.3	71.7	71.4	70.8	70.0	69.3	68.9	68.6	68.2	69.2
Havre, Mont.	42.9	41.3	39.7	38.6	37.7	37.3	36.6	36.5	38.5	41.8	45.5	48.1	50.5	52.5	54.4	55.7	56.5	56.7	56.6	55.6	53.2	49.5	46.8	45.4	46.6
Kansas City, Mo.	51.7	50.7	50.2	49.3	48.7	48.1	47.7	47.5	48.9	51.0	53.9	55.7	57.4	58.7	60.4	61.4	61.6	61.3	60.6	58.7	57.1	55.7	54.0	52.8	54.3
Key West, Fla.	73.3	73.3	73.1	72.9	72.9	73.0	74.0	74.5	76.0	76.6	77.6	78.2	78.1	78.4	78.0	78.1	77.5	76.1	74.9	74.7	74.4	74.1	73.8	73.4	75.3
Memphis, Tenn.	58.9	58.1	57.4	56.8	56.2	55.8	54.9	56.4	57.4	58.8	60.6	62.8	64.4	65.8	66.9	67.1	67.6	67.2	66.1	64.7	63.3	61.7	60.4	59.4	61.2
New Orleans, La.	64.9	64.4	63.9	63.4	63.2	62.9	62.8	63.7	65.9	67.7	69.5	70.9	71.6	71.7	72.6	72.8	72.9	72.5	71.6	69.3	68.0	67.0	66.2	65.4	67.7
New York, N. Y.	45.1	44.3	43.9	43.9	43.4	43.4	43.0	44.1	46.4	48.3	50.8	52.7	53.5	53.8	54.0	54.0	53.2	52.2	50.2	49.7	48.7	48.3	47.4	46.7	48.3
Philadelphia, Pa.	47.2	46.6	46.2	45.5	44.9	44.8	45.8	48.2	50.3	52.6	55.2	56.8	58.8	60.2	61.1	61.4	61.0	59.0	56.1	54.0	51.7	50.4	49.4	48.6	52.3
Pittsburg, Pa.	47.4	46.4	45.7	44.8	44.1	44.0	45.0	46.7	49.2	51.0	53.1	54.6	56.1	57.3	57.2	57.3	56.8	56.0	54.5	53.5	52.3	51.3	50.4	49.2	51.0
Portland, Oreg.	53.7	52.2	51.0	50.1	48.9	48.0	46.7	46.3	45.1	45.7	47.4	49.5	52.4	55.0	56.9	59.0	61.5	62.5	62.6	62.7	61.9	60.0	57.5	55.8	53.8
St. Louis, Mo.	53.4	52.9	52.3	51.5	50.5	49.9	49.6	50.1	51.1	52.4	54.2	56.5	57.7	58.4	59.5	60.4	60.4	60.3	59.3	57.2	56.4	55.5	54.6	53.8	54.9
St. Paul, Minn.	43.4	42.5	41.7	40.8	40.0	39.4	38.7	39.7	41.0	43.2	45.7	47.5	49.0	50.4	51.7	52.6	52.7	52.4	51.6	50.3	48.6	47.2	45.6	44.3	45.8
Salt Lake City, Utah.	46.6	45.8	45.3	44.5	43.7	42.9	41.8	41.6	41.4	44.2	47.3	50.7	53.2	54.3	55.8	56.6	57.0	57.0	57.0	56.0	54.8	52.2	50.0	48.9	49.5
San Diego, Cal.	56.6	56.0	55.4	55.1	54.9	54.7	54.2	53.8	53.4	56.2	58.8	61.6	63.3	64.1	65.0	65.3	65.4	65.1	64.4	63.4	61.9	59.6	59.0	57.8	59.4
San Francisco, Cal.	54.3	53.6	52.7	52.0	51.7	51.6	51.1	51.2	51.3	52.2	54.3	56.4	58.9	60.1	61.4	63.0	63.6	62.9	61.6	60.2	57.9	56.7	55.5	54.9	56.2
Savannah, Ga.	61.7	61.3	60.6	60.1	59.3	58.9	59.5	62.0	64.7	67.2	69.5	71.3	72.4	72.3	72.7	72.1	71.0	69.5	67.2	65.0	64.0	63.6	63.1	62.5	65.5
Washington, D. C.	46.9	46.0	44.8	44.2	43.3	43.1	45.3	48.2	50.9	53.4	56.2	58.6	60.5	62.1	62.7	62.4	61.5	60.3	57.7	56.1	54.0	52.0	50.3	49.0	52.9

TABLE VI.—*Mean pressure for each hour of seventy-fifth meridian time, April, 1897.*

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Bismarck, N. Dak.	28.264	.265	.262	.258	.257	.259	.262	.267	.272	.270	.269	.264	.261	.251	.243	.237	.232	.231	.232	.234	.244	.255	.260	.261	.255
Boston, Mass.	29.921	.916	.912	.914	.920	.932	.940	.945	.945	.938	.924	.911	.901	.892	.884	.881	.882	.885	.885	.902	.914	.917	.917	.917	.913
Buffalo, N. Y.	29.247	.240	.236	.236	.235	.240	.249	.250	.251	.251	.247	.237	.231	.223	.213	.209	.212	.244	.216	.221	.234	.235	.232	.230	.233
Chicago, Ill.	29.165	.155	.154	.154	.153	.164	.178	.187	.183	.183	.188	.181	.171	.164	.154	.145	.144	.144	.141	.145	.156	.162	.159	.155	.162
Cincinnati, Ohio	29.421	.417	.409	.408	.408	.414	.428	.439	.448	.447	.447	.437	.423	.416	.405	.396	.394	.394	.397	.401	.410	.417	.415	.411	.417
Cleveland, Ohio	29.256	.249	.244	.244	.247	.252	.264	.269	.273	.271	.264	.254	.246	.242	.229	.226	.222	.222	.228	.231	.243	.242	.239	.237	.246
Detroit, Mich.	29.283	.277	.268	.268	.267	.275	.286	.292	.290	.290	.282	.284	.276	.269	.259	.252	.252	.254	.252	.257	.265	.267	.268	.265	.271
Dodge City, Kans.	27.392	.394	.398	.397	.400	.400	.407	.414	.422	.424	.425	.425	.409	.393	.381	.367	.353	.346	.349	.354	.364	.384	.401	.400	.392
Eastport, Me.	29.925	.921	.920	.919	.924	.933	.942	.946	.952	.950	.945	.937	.929	.921	.913	.912	.918	.922	.931	.935	.939	.939	.932	.930	.931
Galveston, Tex.	30.035	.030	.025	.014	.016	.024	.035	.053	.059	.066	.073	.077	.067	.051	.043	.026	.012	.006	.005	.008	.019	.034	.040	.041	.036
Havre, Mont.	27.356	.357	.354	.352	.354	.355	.360	.366	.373	.376	.374	.372	.366	.359	.346	.336	.327	.320	.314	.312	.318	.328	.334	.338	.348
Kansas City, Mo.	29.006	.001	.999	.000	.997	.006	.021	.027	.033	.039	.040	.039	.024	.009	.995	.987	.980	.981	.983	.981	.999	.011	.015	.015	.008
Key West, Fla.	30.064	.048	.038	.037	.042	.045	.060	.066	.076	.079	.078	.070	.062	.049	.032	.023	.017	.025	.037	.051	.066	.075	.074	.068	.053
Memphis, Tenn.	29.641	.639	.634	.632	.637	.642	.657	.672	.682	.685	.688	.683	.671	.656	.640	.622	.614	.612	.612	.616	.626	.636	.641	.643	.645
New Orleans, La.	30.021	.013	.006	.003	.008	.020	.033	.049	.057	.067	.069	.063	.049	.036	.016	.001	.989	.989	.993	.996	.009	.021	.025	.025	.023
New York, N. Y.	29.761	.755	.751	.750	.756	.767	.781	.786	.786	.782	.766	.750	.742	.729	.717	.712	.713	.713	.725	.737	.752	.758	.759	.758	.750
Philadelphia, Pa.	29.996	.990	.985	.984	.991	.000	.012	.018	.020	.018	.010	.997	.982	.970	.953	.945	.943	.943	.954	.970	.982	.983	.986	.984	.984
Pittsburg, Pa.	29.205	.199	.195	.196	.200	.206	.216	.216	.216	.214	.212	.198	.186	.171	.162	.157	.161	.164	.173	.185	.198	.194	.188	.184	.191
Portland, Oreg.	29.991	.999	.002	.003	.002	.002	.004	.005	.010	.022	.031	.033	.036	.029	.017	.002	.992	.978	.970	.962	.961	.963	.972	.984	.999
St. Louis, Mo.	29.445	.443	.439	.441	.446	.453	.467	.479	.480	.478	.477	.470	.459	.448	.431	.422	.415	.416	.418	.425	.435	.443	.447	.447	.447
St. Paul, Minn.	29.112	.114	.109	.110	.108	.110	.119	.127	.132	.132	.133	.131	.122	.112	.103	.093	.084	.082	.080	.082	.091	.100	.104	.109	.108
Salt Lake City, Utah	25.693	.695	.698	.695	.697	.696	.700	.709	.718	.720	.723	.726	.724	.716	.708	.693	.681	.670	.674	.671	.667	.672	.682	.688	.696
San Diego, Cal.	29.908	.908	.905	.957	.949	.943	.942	.942	.953	.966	.972	.979	.979	.973	.962	.956	.943	.933	.926	.927	.929	.938	.951	.962	.954
San Francisco, Cal.	29.964	.965	.965	.960	.952	.949	.949	.951	.964	.974	.980	.986	.991	.986	.974	.965	.950	.939	.931	.927	.926	.932	.951	.959	.958
Savannah, Ga.	30.016	.009	.005	.004	.011	.021	.037	.046	.052	.057	.058	.047	.033	.016	.998	.984	.979	.981	.987	.993	.002	.006	.006	.005	.015
Washington, D. C.	30.015	.011	.009	.011	.018	.030	.036	.042	.044	.042	.031	.015	.996	.981	.959	.952	.950	.952	.962	.976	.993	.997	.001	.002	.001

TABLE VII.—*Average wind movement for each hour of seventy-fifth meridian time, April, 1897.*

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Abilene, Tex.	10.5	10.1	9.7	9.7	9.3	9.8	8.9	9.3	10.9	13.1	14.4	14.6	15.0	14.6	14.6	14.6	15.1	15.1	14.7	12.8	10.8	10.3	10.5	10.5	12.0
Albany, N. Y.	7.1	7.2	7.3	6.9	6.6	6.5	6.7	8.4	10.3	11.1	11.2	11.0	11.6	11.7	12.0	12.1	11.4	10.2	8.4	8.3	7.8	7.6	6.8	7.1	9.0
Alpena, Mich.	8.0	7.8	7.9	8.1	8.3	8.6	9.2	9.3	10.1	11.1	12.3	12.6	13.0	13.1	13.0	13.1	12.7	12.2	10.6	9.4	8.7	8.5	7.7	7.7	10.1
Amarillo, Tex.	17.0	16.5	15.8	15.4	15.0	15.5	14.5	14.1	15.2	18.4	19.0	19.4	18.8	18.5	18.2	19.3	19.5	20.4	19.3	18.6	18.0	17.9	17.0	17.4	17.4
Atlanta, Ga.	9.7	9.9	9.6	9.9	10.4	10.6	10.0	9.5	10.4	11.2	11.7	11.6	11.9	11.9	12.2	12.6	12.7	12.7	10.7	9.5	9.3	10.4	9.8	9.6	10.7
Atlantic City, N. J.	11.3	11.0	10.8	10.7	10.8	10.9	11.4	12.6	13.0	12.6	13.3	13.6	14.1	13.2	13.5	13.3	12.5	12.0	11.0	10.2	10.5	10.8	10.5	9.7	11.8
Augusta, Ga.	5.1	4.7	4.7	4.6	4.0	4.1	4.6	5.5	6.7	7.1	7.3	7.7	8.9	8.8	9.3	9.7	9.6	8.8	7.4	6.0	5.2	5.1	5.0	5.1	6.5
Baker City, Oreg.	5.4	6.4	6.9	7.5	6.9	6.9	6.7	7.0	6.8	6.9	5.5	4.5	4.9	5.8	6.4	7.3	8.1	8.2	8.2	8.3	7.9	6.2	4.5	4.4	6.6
Baltimore, Md.	4.2	3.7	3.7	3.3	3.4	2.9	4.1	5.0	5.8	6.3	6.6	6.9	7.8	7.5	8.1	7.4	7.5	7.1	5.9	5.4	5.4	5.3	4.9	4.4	5.5
Bismarck, N. Dak.	8.4	8.3	7.6	7.0	6.7	6.6	7.2	7.5	8.7	10.1	10.9	11.9	13.1	14.2	15.6	15.6	15.9	15.0	14.5	12.8	10.5	9.5	8.9	8.7	10.6
Block Island, R. I.	11.6	11.9	12.4	12.5	13.7	13.7	14.8	15.0	15.3	15.7	15.5	15.2	16.1	17.0	17.6	17.8	17.6	16.5	15.3	14.8	13.3	12.9	12.6	12.1	14.6
Boston, Mass.	11.1	10.7	10.2	10.1	9.6	10.0	10.9	11.1	11.8	12.0	12.7	13.3	13.5	14.1	14.5	14.4	13.9	12.5	11.3	10.7	11.4	11.6	11.3	10.3	11.8
Buffalo, N. Y.	14.1	14.4	14.1	14.3	14.4	14.0	13.9	14.3	16.1	16.4	16.5	17.1	17.8	17.3	16.0	15.5	15.2	15.4	15.5	15.3	15.3	15.4	14.0	14.5	15.3
Cairo, Ill.	10.6	11.1	11.3	11.2	10.3	10.0	9.7	10.4	11.3	11.8	11.4	10.9	11.4	11.5	12.2	12.9	12.4	11.6	10.7	10.4	10.5	11.0	10.7	10.2	11.1
Cape Henry, Va.	13.7	14.1	15.5	15.4	15.0	14.8	14.5	14.9	14.6	14.1	14.3	13.8	13.2	13.5	13.6	13.6	14.2	12.9	12.4	12.0	12.3	12.1	12.7	13.8	13.8
Charleston, S. C*.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Charlotte, N. C.	7.1	7.2	6.6	6.5	5.9	5.3	5.5	6.8	8.1	8.9	8.8	8.2	7.9	9.2	8.7	9.3	9.0	8.5	7.4	6.5	5.9	7.0	6.9	6.6	7.4
Chattanooga, Tenn.	6.0	5.6	6.1	6.1	5.3	5.4	4.9	5.8	7.3	8.5	9.4	10.2	11.6	11.9	12.8	11.7	11.9	11.1	10.1	7.9	7.2	6.1	5.3	5.5	8.1
Cheyenne, Wyo.	10.4	10.1	10.3	10.6	10.0	9.7	9.9	8.3	9.5	12.0	12.2	13.0	14.8	14.6	14.9	15.0	14.8	15.3	14.6	14.1	11.4	9.6	10.0	10.0	11.9
Chicago, Ill.	18.7	19.1	19.2	18.9	19.4	19.3	20.0	19.8	20.4	21.8	22.2	22.1	23.0	22.0	22.8	21.9	21.8	21.5	20.5	20.1	19.3	18.4	18.2	18.1	20.4
Cincinnati, Ohio.	7.4*	7.2	6.9	7.0	6.8	7.0	6.9	7.8	8.8	10.2	11.7	12.2	12.2	12.4	12.7	12.2	12.1	11.3	10.5	9.1	8.8	8.0	8.4	7.4	9.4
Cleveland, Ohio.	14.6	15.2	14.7	14.6	14.3	15.1	15.4	16.6	16.8	17.0	17.7	16.7	16.7	17.5	17.8	17.6	16.0	14.4	12.6	13.2	13.9	13.7	14.1	13.9	15.4
Columbia, Mo.	10.3	10.4	10.1	10.0	10.4	10.9	10.7	11.0	12.2	12.5	12.9	13.4	13.6	14.7	14.5	14.5	14.6	13.6	12.2	11.3	10.0	9.5	9.5	10.4	11.8
Columbus, Ohio.	6.4	7.0	7.0	7.4	7.1	7.4	7.1	8.4	9.2	9.7	9.9	10.4	10.9	11.4	11.5	10.6	11.0	9.9	8.6	7.7	7.2	7.3	6.9	6.4	8.6
Concordia, Kans.	9.4	8.4	7.7	7.2	7.5	7.3	7.3	7.4	8.4	10.7	11.8	12.1	12.0	12.0	11.3	11.7	12.0	12.2	11.9	10.9	8.2	8.5	8.8	9.1	9.7
Corpus Christi, Tex.	13.7	12.4	12.6	11.7	11.4	11.3	12.0	10.9	11.8	12.6	13.5	14.2	15.2	16.1	16.3	16.6	17.9	17.6	17.0	15.8	14.7	14.2	14.6	13.7	14.1
Davenport, Iowa.	9.4	9.5	8.8	9.3	9.0	8.6	9.3	9.3	10.0	11.2	11.5	11.9	12.0	12.3	12.4	12.3	11.1	10.6	10.1	8.7	8.7	8.3	8.4	8.5	10.1
Denver, Colo.	7.5	7.7	7.6	7.4	7.6	7.1	6.4	6.2	6.9	7.2	6.9	6.9	8.6	9.9	10.8	11.6	12.4	12.8	12.8	12.4	11.4	9.8	8.7	6.6	8.9
Des Moines, Iowa.	9.5	9.1	9.7	9.3	9.6	10.0	9.6	9.8	10.1	11.5	12.5	13.0	13.4	13.2	12.9	13.4	13.5	13.2	12.6	11.2	9.9	9.2	9.2	8.2	11.0
Detroit, Mich.	9.5	9.3	8.8	9.6	9.5	9.3	9.6	9.6	10.6	11.6	12.5	12.5	13.2	12.7	12.4	12.7	12.7	11.8	10.5	10.1	10.1	10.1	9.8	9.7	10.8
Dodge City, Kans.	11.6	11.6	11.6	11.3	10.0	10.1	10.9	11.6	14.0	15.8	16.5	16.6	15.8	15.5	15.1	14.8	14.3	13.8	13.3	12.4	11.0	11.6	11.2	11.1	13.0
Dubuque, Iowa.	8.0	8.1	7.9	7.7	7.8	7.8	7.3	8.5	9.4	10.6	11.1	11.1	11.5	11.4	11.7	11.4	11.0	10.9	9.8	8.3	7.7	7.9	8.3	8.2	9.3
Duluth, Minn.	8.5	9.3	9.9	10.7	10.5	9.9	10.5	11.3	13.2	13.8	13.9	14.7	14.7	15.0	13.9	14.4	13.5	13.1	12.3	10.8	9.8	9.6	9.8	8.8	11.7
Eastport, Me.	10.5	10.0	9.8	9.9	10.0	10.4	10.5	10.1	10.4	10.9	11.4	12.0	12.7	13.1	13.2	13.0	12.0	11.3	11.0	10.5	10.6	9.3	9.9	10.5	11.0
El Paso, Tex.	11.1	11.2	11.2	10.4	10.7	10.5	10.2	9.9	9.4	9.9	12.5	13.2	13.4	14.7	15.5	16.1	16.5	16.4	16.4	16.2	14.1	11.9	10.9	10.7	12.6
Erie, Pa.	11.2	11.3	12.4	12.3	12.6	11.7	11.3	11.7	12.8	12.8	13.6	13.8	15.2	14.5	13.6	13.3	13.3	12.1	10.7	10.2	10.2	10.6	10.5	10.9	12.2
Eureka, Cal.	6.1	4.7	4.6	3.5	3.5	3.3	3.3	3.5	2.8	3.3	3.2	4.2	6.8	8.7	10.7	12.2	12.5	12.8	13.2	12.5	10.7	9.2	8.4	7.0	7.1
Fort Canby, Wash.	13.5	13.3	11.8	11.2	10.9	10.2	10.7	11.1	10.6	10.6	11.1	10.7	10.4	11.0	11.3	11.5	12.0	13.1	13.4	12.6	13.1	13.7	13.2	12.8	11.8
Fort Smith, Ark.	6.0	6.5	5.7	5.9	5.9	6.3	5.9	6.2	7.2	7.8	9.1	9.8	10.8	10.7	11.2	10.8	11.5	10.9	10.2	9.1	7.2	7.0	6.3	6.4	8.1
Fresno, Cal.	6.3	6.3	6.6	5.6	4.9	4.6	4.3	4.1	3.3	3.8	4.6	5.0	5.4	5.3	5.6	5.8	6.0	6.8	6.9	7.4	6.9	6.2	6.1	6.1	5.6
Galveston, Tex.	11.3	11.1	11.0	10.9	10.2	9.2	10.1	10.6	10.9	11.6	12.0	12.5	12.5	12.3	12.4	13.1	13.0	12.9	12.7	12.2	11.7	12.2	11.8	11.2	11.6
Grand Haven, Mich.	11.0	11.3	11.2	11.6	11.0	10.8	10.1	11.0	12.5	13.1	13.3	13.9	14.3	15.3	14.6	14.7	13.9	13.2	12.4	11.7	10.9	10.8	10.6	11.0	12.3
Greenbay, Wis.	9.0	8.5	8.6	9.2	9.6	9.4	9.3	9.1	10.4	10.8	11.3	11.9	12.6	12.3	11.8	11.3	11.5	11.1	10.6	9.5	9.7	9.1	9.3	8.6	10.2
Hannibal, Mo.	11.3	11.7	12.2	12.3	11.3	11.6	11.8	12.3	13.0	14.3	14.2	13.8	14.7	14.4	14.6	14.6	14.5	13.4	12.0	11.0	11.1	10.0	10.9	11.3	12.6
Harrisburg, Pa.	6.6	6.3	6.4	6.4	5.9	5.3	5.7	6.2	7.1	7.7	8.3	8.0	9.3	10.7	10.7	10.3	10.2	9.1	7.9	8.0	8.7	7.8	6.8	6.5	7.8
Hatteras, N. C.	9.7	10.5	11.5	12.3	12.8	13.9	13.7	14.1	14.4	14.5	14.3	14.7	13.8	14.0	13.6	13.2	12.1	11.1	10.2	9.9	9.5	9.4	9.3	9.1	12.2
Havre, Mont.	9.2	9.0	8.2	9.0	9.1	9.0	9.7	9.1	9.9	11.3	13.1	14.5	15.7	16.2	16.5	16.3	15.3	15.5	14.1	13.3	11.5	8.9	9.2	8.5	11.8
Helena, Mont*.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Huron, S. Dak.	12.3	11.3	10.7	10.4	10.8	11.0	10.6	10.3	10.8	13.1	13.5	13.6	14.7	15.8	15.5	15.3	15.7	15.1	14.5	13.4	11.9	10.9	11.4	11.7	12.7
Idaho Falls, Idaho.	7.2	7.6	7.5	7.4	7.0	7.4	7.1	7.1	7.7	8.8	9.0	9.2	11.3	11.4	12.4	13.2	13.5	13.4	13.5	12.7	11.2	8.7	7.6	7.3	9.6
Indianapolis, Ind.	11.2	10.5	10.2	9.9	10.2	10.1	10.3	11.3	12.5	14.0	15.1	15.0	15.8	15.6	15.1	15.3	15.1	14.5	13.2	11.7	10.9	11.8	11.2	11.1	12.6
Jacksonville, Fla.	6.8	6.6	6.9	6.8	6.4	6.5	6.2	6.7	7.8	9.4	10.4	11.3	12.3	11.4	11.3	11.5	11.5	11.1	9.5	7.4	6.5	6.5	6.2	6.3	8.5
Jupiter, Fla.	11.3	11.2	11.8	11.1	10.7	9.7	9.9	10.1	11.7	13.1	13.2	13.9	13.8	13.5	14.2	13.9	14.1	13.5	12.7	13.1	13.7	12.8	11.8	11.7	12.3
Kansas City, Mo.	10.2	10.2	9.9	9.4	9.5	9.0	8.5	9.0	9.1	10.0	11.2	12.1	13.0	13.1	13.4	13.8	13.9	12.8	12.2	10.8	10.1	10.2	10.7	10.1	10.9
Keokuk, Iowa.	10.2	9.6	9.8	9.3	8.7	8.9	8.9	9.6	10.6	11.3	11.1	11.8	12.2	12.5	12.5	12.1	11.4	11.2	10.3	9.8	9.0	9.2	9.6	10.5	10.4
Key West, Fla.	11.9	12.1	11.6	11.8	12.3	12.4	11.9	12.8	13.1	13.7	14.1	13.6	13.7	13.5	12.1	11.8	11.4	10.9	11.1	11.2	10.9	11.2	12.4	12.1	12.2
Kittyhawk, N. C.	12.6	14.2	15.2	15.7	16.2	16.7	16.8	17.7	17.4	17.1	15.8	14.2	16.0	15.9	14.9	14.8	14.5	13.9	14.1	13.6	13.7	13.7	12.8	13.2	15.0
Knoxville, Tenn.	4.1	3.6	4.2	4.3	3.9	4.1	4.8	5.4	6.4	6.9	7.5	8.1	8.2	8.6	8.2	8.4	7.9	7.9	7.2	5.2	4.7	4.0	4.0	3.5	5.9
La Crosse, Wis.	8.8	8.9	8.8	8.6	8.2	9.3	9.0	9.2	9.7	9.8	10.0	11.0	11.4	12.0	12.1	11.9	11.3	11.2	10.3	9.8	8.9	8.6	8.5	8.5	9.8
Lander, Wyo.	4.3	3.8	3.4	3.1	3.6	3.0	2.6	2.8	2.7	3.1	4.8	5.0	5.5	5.7	6.2	7.0	6.3	6.4	6.5	7.2	6.9	4.9	4.9	4.9	4.8
Lexington, Ky.	12.5	12.4	12.9	12.4	12.1	12.6	12.5	12.8	13.2	14.0	15.1	15.3	15.4	15.0	14.3	14.8	14.1	13.5	12.3	11.5	11.5	10.6	11.3	11.6	13.1
Little Rock, Ark.	6.3	6.8	6.3	6.2	6.6	6.5	6.4	6.6	7.8	8.8	9.9	9.4	10.2	10.7	11.0	10.9	10.7	9.6	9.2	8.2	7.6	7.4	7.1	7.3	8.2
Los Angeles, Cal.	2.6	3.0	3.0	2.7	2.7	2.7	2.2	2.8	2.9	2.9	3.5	4.0	4.3	5.1	6.2	7.7	8.8	8.6	8.4	7.8	6.6	4.8	3.4	3.0	4.6
Louisville, Ky.	8.4	8.5	8.2	8.2	8.5	8.3	8.6	9.3	10.3	11.4	12.0	12.0	12.7	12.8	13.0	13.3	13.0	11.9	10.4	9.7	9.0	8.8	8.3	8.7	10.2
Lynchburg, Va.	3.9	3.2	2.9	2.7	2.6	3.0	3.0	3.5	4.7	5.2	5.7	5.9	6.4	6.5	6.5	6.9	7.4	7.5	7.2	6.2	5.0	4.8	4.4	3.9	5.0
Marquette, Mich.	9.9	9.9	10.3	10.9	10.7	10.2	10.8	10.8	11.3	11.6	13.2	14.6	14.7	15.2	14.8	14.3	13.3	11.6	10.3	9.6	9.2	9.3	10.1	10.0	11.5
Memphis, Tenn.	11.9	11.5	11.4	11.5	10.5	10.8	10.5	10.0	10.5	10.9	11.4	10.9	11.4	11.8	11.2	11.7	11.7	11.0	10.4	9.5	9.3	10.5	10.5	11.2	10.9
Milwaukee, Wis.	10.4	10.0	10.6	10.2	10.4	10.4	10.6	10.9	11.5	12.5	12.7	13.5	14.5	14.5	15.0	14.7	13.9	12.4	10.9	9.8	9.5	9.5	10.2	10.0	11.6
Mobile, Ala.	6.3	5.6	5.3	5.7	5.6	5.7	5.8	6.3	7.3	8.0	8.6	10.3	10.8	11.0	12.1	12.3	12.6	12.5	11.7	10.0	8.7	7.8	7.6	7.0	8.5
Montgomery, Ala.	5.6	5.9	5.4	5.2	4.9	5.2	4.9	5.7	6.3	7.2	7.8	8.0	8.7	9.1	9.0	9.6	9.7	8.8	7.4	6.7	6.6	6.7	6.2	6.1	7.0
Moorhead, Minn.	11.5	11.7	10.8	10.4	11.1	10.7	10.9	11.5	12.9	13.5	13.4	13.5	13.5	13.9	14.6	14.0	13.5	14.3	13.3	12.9	11.7	11.0	10.6	11.1	12.3
Nantucket, Mass.	9.7	9.8	10.0	10.5	10.1	10.9	11.8	12.3	12.9	12.9	13.4	13.2	13.1	13.3	13.4	12.7	11.9	10.8	9.7	9.5	9.6	9.1	9.0	8.9	11.2
Nashville, Tenn.	7.1	7.7	8.2	7.8	7.1	6.4	6.0	7.0	8.3	9.6	10.0	10.9	11.1	11.1	11.1	10.4	10.3	10.7	10.6	8.9	7.9	7.3	7.1	6.9	8.7
New Haven, Conn.	8.1	7.0	6.4	6.6	7.0	7.3	8.2	9.2	9.8	10.2	11.6	13.2	13.9	14.2	14.3	14.1	13.4	11.9	11.0	10.8	8.5	7.9	7.2	7.6	10.0
New Orleans, La.	8.4	8.2	8.4	8.4	8.1	7.7	7.3	7.5	8.8	10.4	11.2	11.8	11.8	11.9	11.2	10.9	11.4	11.4	10.9	9.7	8.7	9.0	9.1	8.8	9.6
New York, N. Y.	12.4	11.2	10.8	11.1	11.6	11.6	12.9	13.4	12.4	12.0	12.5	13.0	14.1	15.4	16.7	17.1	17.4	16.4	16.7	15.4	14.1	12.2	11.3	11.5	13.5
Norfolk, Va.	7.9	7.7	8.2	7.8	7.7	7.3	8.3	9.1	9.4	9.2	9.4	9.2	9.0	10.0	10.5	11.0	11.0	10.4	8.8	8.0	8.0	8.1	7.8	7.4	8.8
Northfield, Vt.	7.1	6.8	6.5	6.4	5.9	6.2	5.6	7.5	9.5	10.3	11.6	12.7	12.9	13.5	13.7	12.7	12.5	11.1	9.4	8.8	8.6	7.5	7.1	7.4	9.2
North Platte, Nebr.	10.6	10.0	9.7	10.1	9.2	8.4	8.9	9.2	9.7	11.6	13.3	13.5	14.1	14.4	14.4	14.5	14.2	13.7	13.9	12.5	10.7	10.6	11.0	10.8	11.6
Oklahoma, Okla.	10.7	10.1	9.7	9.5	9.0	9.7	9.6	9.4	10.4	12.8	14.7	15.6	15.8	15.1	15.0	15.3	15.3	15.4	14.5	13.1	11.3	10.9	10.3	10.5	12.2
Omaha, Nebr.	8.5	9.4	9.0	8.8	9.5	9.6	9.3	9.3	10.2	11.6	12.1	12.2	12.6	13.1	12.6	12.5	11.8	11.3	10.3	10.3	8.2	8.8	9.4	8.9	10.4
Oswego, N. Y.	11.2	11.5	11.2	11.1	10.8	11.0	10.9	11.3	12.1	12.7	13.4	13.1	13.7	14.2	13.6	13.1	12.6	11.5	10.4	9.9	10.3	10.8	11.3	11.3	11.8
Palestine, Tex.	6.0	5.8	6.0	5.6	5.8	6.0	6.2	6.1	7.1	8.9	9.6	9.9	9.8	10.5	10.6	10.4	10.5	9.4	8.7	6.8	6.1	6.8	6.7	6.7	7.8
Parkersburg, W. Va.	5.0	5.0	4.7	4.8	4.6	4.8	4.7	5.6	6.6	7.3	7.6	7.8	9.0	9.5	8.9	8.5	9.3	9.0	7.3	5.4	4.9	5.0	4.5	4.7	6.4
Pensacola, Fla.	9.8	9.0	8.7	9.2	9.7	9.3	9.5	10.3	10.8	12.0	12.4	12.1	12.3	12.7	13.5	13.4	13.1	11.6	11.0	10.1	9.2	10.1	9.7	10.2	10.8

*Report not received in time for publication.

TABLE VII.—*Average wind movement, etc.*—Continued.

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Philadelphia, Pa.....	9.6	9.3	9.8	9.8	9.6	9.1	9.5	10.9	12.2	12.3	12.0	11.7	12.1	12.2	12.6	12.2	12.1	12.6	11.6	11.3	10.4	9.0	9.2	9.2	10.9
Phœnix, Ariz.....	3.3	3.5	3.5	4.3	3.7	3.6	3.8	3.7	4.0	4.0	4.9	5.0	5.1	4.5	4.9	6.0	6.6	6.5	6.6	6.3	4.8	4.2	3.5	3.2	4.6
Pierre, S. Dak.....	10.1	9.5	9.2	8.6	8.5	8.6	9.2	8.8	9.6	11.3	11.1	12.4	13.9	13.7	14.5	15.2	14.0	14.5	15.0	13.9	10.9	10.5	9.6	9.4	11.3
Pittsburg, Pa.....	5.4	5.5	5.3	5.2	5.4	5.2	5.6	6.2	7.1	7.7	8.5	8.7	8.7	9.3	9.5	9.2	8.5	7.8	7.6	7.2	7.0	6.2	5.8	5.6	7.0
Port Angeles, Wash..	5.9	6.0	5.9	5.8	5.7	6.5	6.0	6.2	5.5	5.4	5.4	6.2	8.0	8.0	8.0	8.7	8.4	8.2	8.4	7.7	7.1	6.2	5.9	6.4	6.7
Port Huron, Mich....	10.4	10.6	10.3	11.1	10.2	10.6	10.6	10.9	11.4	12.9	14.0	14.6	15.5	14.6	14.6	14.6	14.3	12.9	11.1	10.8	10.6	11.1	10.8	10.5	12.0
Portland, Me.....	6.8	7.0	6.6	6.5	6.3	6.1	6.4	7.0	8.1	8.6	9.1	10.2	10.8	11.1	10.8	10.7	10.2	9.8	8.2	7.5	6.9	7.2	6.4	6.6	8.1
Portland, Oreg.....	9.5	8.9	8.9	8.0	7.6	7.0	6.8	6.5	6.4	6.4	7.4	8.2	8.7	8.5	8.8	9.6	9.8	10.1	10.4	9.8	9.5	9.5	8.8	10.0	8.5
Pueblo, Colo.....	6.5	6.8	7.5	7.2	7.2	7.0	5.8	5.8	5.4	6.0	6.7	6.3	8.0	9.2	10.3	11.6	12.6	13.4	14.5	14.2	12.5	11.3	9.0	7.8	8.8
Raleigh, N. C.....	6.5	6.4	6.5	5.9	5.8	5.5	5.5	6.3	7.2	7.7	7.6	7.7	8.0	7.6	7.9	8.1	7.9	7.0	6.0	5.4	5.7	6.0	7.1	6.9	6.8
Rapid City, S. Dak...	7.6	7.4	7.2	8.0	7.5	7.7	7.8	7.7	7.7	8.4	9.7	10.1	11.4	12.1	12.6	12.9	12.9	12.7	12.9	11.5	9.2	7.1	6.5	6.8	9.4
Redbluff, Cal.....	5.3	5.7	5.5	5.4	6.2	6.5	6.4	6.1	6.0	6.2	7.5	8.0	8.1	8.5	8.2	8.1	8.1	8.1	8.1	8.0	7.1	5.9	5.7	5.3	6.8
Rochester, N. Y.....	7.1	7.3	7.4	7.9	8.0	8.1	8.0	9.0	9.6	10.2	10.9	11.3	11.8	11.8	12.1	10.8	10.4	8.9	7.6	6.9	7.2	7.5	6.9	6.5	8.9
Roseburg, Oreg.....	2.1	1.9	1.9	1.7	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.9	3.5	4.4	4.8	5.5	6.4	7.2	7.1	6.8	7.1	6.4	4.7	3.3	3.8
Sacramento, Cal.....	9.2	9.4	9.6	9.6	10.0	9.2	9.3	9.6	9.1	9.3	9.8	10.8	11.6	11.4	11.7	11.4	11.0	10.6	10.5	9.8	9.8	9.4	9.6	9.4	10.0
St. Louis, Mo.....	10.9	10.6	10.7	10.8	11.3	11.2	11.6	12.8	13.2	14.6	14.8	14.2	14.2	14.1	14.8	14.0	13.2	13.2	13.6	12.9	11.8	11.6	11.1	10.4	12.6
St. Paul, Minn.....	6.8	7.0	7.3	7.2	7.6	7.8	8.0	8.6	10.0	10.1	10.7	11.8	12.1	12.4	12.4	12.1	12.2	11.8	11.0	9.4	7.7	7.6	8.0	7.6	9.5
Salt Lake City, Utah.	5.4	4.7	5.7	5.5	5.4	5.6	5.8	5.4	5.4	5.2	5.8	7.0	8.6	9.4	9.8	10.2	11.1	11.0	11.1	10.8	8.6	5.7	5.6	5.1	7.2
San Antonio, Tex.....	8.8	8.2	8.3	7.6	7.7	6.9	6.8	6.9	7.2	9.3	11.4	11.6	12.7	13.5	13.5	13.2	13.0	13.0	13.0	11.7	11.0	11.5	11.3	9.5	10.3
San Diego, Cal.....	2.2	2.4	2.7	2.5	2.6	2.3	2.7	2.6	2.8	2.6	2.6	3.4	6.3	8.3	9.3	10.2	10.0	9.8	9.1	8.0	6.8	4.8	3.6	3.0	5.0
Sandusky, Ohio	8.7	9.1	9.7	9.5	9.2	9.5	9.3	9.9	10.4	11.0	11.5	12.2	13.0	12.4	12.3	11.9	11.5	11.1	10.3	9.8	9.4	9.0	9.0	9.0	10.4
San Francisco, Cal...	10.1	8.8	8.5	7.6	7.5	7.3	7.1	7.3	7.3	7.8	8.3	8.1	8.7	9.8	12.3	13.4	15.5	16.3	17.4	18.5	19.1	17.8	15.5	10.8	11.3
San Luis Obispo, Cal.	3.3	3.8	3.5	3.5	3.5	3.7	3.8	4.0	3.8	3.6	4.5	4.8	5.7	6.2	7.1	8.3	8.9	8.9	8.2	7.9	7.1	5.9	4.1	3.5	5.3
Santa Fe, N. Mex.....	5.7	5.8	5.1	4.7	4.3	4.7	4.9	5.0	4.7	6.0	8.2	9.3	11.3	12.0	13.7	12.0	12.1	12.9	11.9	11.3	8.4	6.5	6.2	5.6	8.0
Sault Ste Marie, Mich.	7.9	7.8	8.1	7.6	7.9	7.2	7.8	8.5	9.7	10.2	10.6	11.5	12.2	12.2	12.3	13.0	12.7	12.2	11.3	9.9	9.0	8.5	8.0	7.2	9.7
Savannah, Ga.....	8.1	8.1	8.1	8.3	7.8	7.9	8.0	8.4	9.1	9.8	10.0	10.3	11.4	12.0	11.9	12.3	12.2	11.8	9.8	8.8	8.9	9.2	9.0	8.6	9.6
Seattle, Wash.....	3.9	4.0	3.8	4.2	3.5	3.7	4.0	3.8	3.4	4.1	4.1	4.6	5.6	5.6	6.3	7.2	7.2	7.4	7.5	7.2	6.8	6.2	5.6	4.9	5.2
Shreveport, La.....	6.5	6.3	6.9	7.4	7.1	6.6	6.0	6.8	8.4	8.2	8.9	9.3	9.7	9.5	10.0	10.7	10.5	9.0	8.6	6.9	6.4	6.9	7.6	7.3	8.0
Sioux City, Iowa.....	14.8	15.3	13.7	13.6	13.8	14.1	13.8	14.2	15.1	16.3	17.5	18.0	19.1	19.1	19.3	19.8	19.5	19.2	17.2	15.2	14.0	13.4	13.2	13.1	15.9
Spokane, Wash.....	4.0	3.8	3.6	3.9	4.4	4.5	5.1	4.9	5.1	5.4	5.9	6.8	7.6	7.6	8.3	8.6	9.1	9.2	8.3	8.1	6.9	5.3	4.7	4.7	6.1
Springfield, Ill.....	11.0	11.2	10.8	11.0	10.8	10.5	11.2	11.7	12.6	14.3	14.6	15.0	14.9	14.4	14.6	14.8	14.9	14.1	12.5	10.5	10.0	10.2	10.4	10.6	12.4
Springfield, Mo.....	10.4	10.6	10.1	11.6	11.0	10.9	11.6	12.0	12.9	14.0	14.7	15.3	15.7	15.7	15.8	16.4	16.2	16.0	15.2	13.0	10.9	10.7	10.4	10.7	13.0
Tampa, Fla.....	5.3	4.9	5.3	5.9	6.1	5.8	6.2	7.3	8.7	9.6	9.3	9.3	10.8	10.6	11.0	10.6	10.5	9.5	8.8	7.4	7.0	6.6	6.2	5.0	7.8
Tatoosh Island, Wash.	12.7	13.3	12.5	12.8	12.8	12.1	12.0	13.0	13.7	13.8	13.8	14.0	14.3	14.1	13.5	14.5	14.4	13.2	12.1	13.4	12.1	13.1	13.5	12.4	13.2
Toledo, Ohio.....	10.3	10.4	10.1	10.0	10.4	10.1	10.4	10.9	12.6	13.2	14.2	14.1	14.6	14.8	14.3	14.3	14.0	12.8	11.5	10.7	9.7	9.8	10.0	10.4	11.8
Vicksburg, Miss.....	7.8	7.6	7.3	7.2	7.1	7.4	7.2	7.3	8.3	8.5	8.2	7.8	8.8	8.0	7.9	8.1	7.8	7.4	6.8	6.6	7.0	7.5	7.7	7.7	7.6
Vineyard Haven, Mass	7.2	7.5	7.7	7.8	7.5	7.8	9.4	10.6	10.3	10.9	11.2	11.5	12.1	12.1	12.3	11.9	11.3	9.7	8.2	7.7	7.5	7.3	7.5	7.8	9.4
Walla Walla, Wash...	5.1	5.4	5.6	5.5	5.2	4.8	5.2	5.8	5.9	6.1	6.6	7.9	8.2	8.5	8.2	8.0	7.8	8.1	7.3	7.4	7.0	6.2	6.6	6.2	6.6
Washington, D. C.....	6.4	5.8	5.7	5.5	5.4	4.7	5.5	7.0	8.0	8.5	8.4	8.8	9.9	10.1	10.4	11.2	10.8	10.0	8.2	7.3	6.8	7.4	7.7	7.1	7.8
Wichita, Kans.....	10.0	9.5	9.3	9.0	8.8	9.4	9.1	9.9	10.6	12.7	13.6	14.9	16.1	16.3	15.9	16.0	15.2	14.4	14.0	11.6	10.3	10.2	9.1	9.8	11.9
Williston, N. Dak.....	7.4	7.4	6.9	7.8	8.0	7.9	8.2	8.6	9.4	10.8	11.6	12.0	13.9	14.7	15.0	14.9	14.4	14.8	14.4	13.0	10.0	9.6	8.8	7.5	10.7
Wilmington, N. C.....	7.3	7.1	7.5	7.3	7.1	7.6	7.6	8.0	9.2	9.5	9.8	10.2	10.8	12.0	12.3	11.5	11.2	11.0	9.5	8.1	7.7	7.6	7.0	7.0	8.9
Woods Hole, Mass.....	13.5	13.1	13.4	13.1	13.1	13.1	14.1	15.5	15.3	16.1	15.7	16.0	18.2	18.2	18.0	18.3	16.8	15.7	14.0	13.8	13.6	13.3	14.3	13.3	15.0
Yankton, S. Dak.....	10.6	10.7	10.6	10.9	10.5	10.8	10.6	9.7	10.9	11.9	12.9	13.5	14.0	14.0	14.3	14.3	14.1	13.2	13.6	11.9	10.1	9.6	9.5	10.3	11.8

TABLE VIII.—*Resultant winds from observations at 8 a. m. and 8 p. m., daily, during the month of April, 1897.*

Stations.	Component direction from—				Resultant.	
	N.	S.	E.	W.	Direction from—	Duration.
New England.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	°	*Hours.*
Eastport, Me	20	20	13	23	w.	10
Portland, Me	19	23	11	21	s. 68 w.	11
Northfield, Vt	25	27	5	11	s. 72 w.	6
Boston, Mass	17	17	11	30	w.	19
Nantucket, Mass	16	24	9	27	s. 66 w.	20
Woods Hole, Mass.*	5	19	4	7	s. 12 w.	14
Block Island, R. I	17	19	6	36	s. 86 w.	30
New Haven, Conn	26	22	5	17	n. 72 w.	13
Middle Atlantic States.						
Albany, N. Y	26	18	1	21	n. 68 w.	22
Binghamton, N. Y†	12	6	4	12	n. 53 w.	10
New York, N. Y	21	23	11	23	s. 81 w.	12
Harrisburg, Pa	15	17	19	24	s. 68 w.	5
Philadelphia, Pa	20	23	13	20	s. 67 w.	8
Atlantic City, N. J	17	21	11	28	s. 77 w.	18
Baltimore, Md	15	13	21	21	n.	2
Washington, D. C	22	20	16	13	n. 56 e.	4
Lynchburg, Va	18	20	23	18	s. 68 e.	5
Norfolk, Va	15	25	25	11	s. 54 e.	17
South Atlantic States.						
Charlotte, N. C	11	27	25	8	s. 47 e.	23
Hatteras, N. C	22	16	23	11	n. 63 e.	13
Kittyhawk, N. C	18	23	25	10	s. 72 e.	16
Raleigh, N. C	19	20	20	17	s. 72 e.	3
Wilmington, N. C	17	24	21	11	s. 55 e.	12
Charleston, S. C	16	25	20	10	s. 48 e.	14
Augusta, Ga	10	22	22	20	s. 9 e.	12
Savannah, Ga	18	24	20	12	s. 53 e.	10
Jacksonville, Fla	20	23	21	13	s. 69 e.	8
Florida Peninsula.						
Jupiter, Fla	14	20	25	14	s. 61 e.	12
Key West, Fla	17	11	38	3	n. 80 e.	36
Tampa, Fla	25	15	23	13	n. 51 e.	13
Eastern Gulf States.						
Atlanta, Ga	16	16	22	23	w.	1
Pensacola, Fla	19	28	13	15	s. 13 w.	9
Mobile, Ala	25	24	17	8	n. 84 e.	9
Montgomery, Ala	16	22	20	16	s. 34 e.	7
Vicksburg, Miss	17	21	23	13	s. 68 e.	11
New Orleans, La	18	19	25	14	s. 85 w.	12
Western Gulf States.						
Shreveport, La	14	29	21	13	s. 28 e.	17
Fort Smith, Ark	17	13	22	19	n. 37 e.	5
Little Rock, Ark	17	20	16	18	s. 34 w.	4
Corpus Christi, Tex	12	27	35	2	s. 66 e.	36
Galveston, Tex	14	32	24	5	s. 47 e.	26
Palestine, Tex	18	28	17	8	s. 42 e.	14
San Antonio, Tex	23	22	27	4	n. 88 e.	23
Ohio Valley and Tennessee.						
Chattanooga, Tenn	17	20	19	17	s. 34 e.	4
Knoxville, Tenn	27	5	21	20	n. 3 e.	22
Memphis, Tenn	18	22	18	16	s. 27 e.	4
Nashville, Tenn	20	21	14	19	s. 79 w.	5
Lexington, Ky	17	21	20	21	s. 14 w.	4
Louisville, Ky	21	22	16	13	s. 72 e.	3
Indianapolis, Ind	22	19	13	17	n. 53 w.	5
Cincinnati, Ohio	16	21	21	15	s. 50 e.	8
Columbus, Ohio	14	19	16	24	s. 58 w.	9
Pittsburg, Pa	11	26	13	26	s. 41 w.	20
Parkersburg, W. Va	19	22	19	16	s. 45 e.	4
Lower Lake Region.						
Buffalo, N. Y	11	26	12	27	s. 45 w.	21
Oswego, N. Y	16	22	7	24	s. 71 w.	18
Rochester, N. Y	14	22	12	30	s. 66 w.	20
Erie, Pa	13	30	11	23	s. 60 w.	14
Cleveland, Ohio	15	23	16	19	s. 21 w.	8
Sandusky, Ohio	13	20	21	20	s. 8 e.	7
Toledo, Ohio	14	18	21	22	s. 14 w.	4
Detroit, Mich	20	21	13	19	s. 80 w.	6
Upper Lake Region.						
Alpena, Mich	21	19	17	17	n.	2
Grand Haven, Mich	18	18	18	19	w.	1
Marquette, Mich	30	13	7	22	n. 42 w.	23
Port Huron, Mich	21	25	12	13	s. 14 w.	4
Sault Ste. Marie, Mich	18	17	29	15	n. 86 e.	14
Chicago, Ill	20	21	19	17	s. 68 e.	2
Milwaukee, Wis	19	19	21	15	e.	6
Upper Lake Region—Cont'd.						
Greenbay, Wis	23	19	14	15	n. 14 w.	4
Duluth, Minn	33	8	21	18	n. 7 e.	25
North Dakota.						
Moorhead, Minn	22	16	20	19	n. 9 e.	6
Bismarck, N. Dak	25	15	17	18	n. 6 w.	10
Williston, N. Dak	30	14	13	10	n. 11 e.	16
Upper Mississippi Valley.						
St. Paul, Minn	27	15	12	23	n. 43 w.	16
La Crosse, Wis. †	13	12	6	6	n.	1
Davenport, Iowa	15	15	24	18	e.	6
Des Moines, Iowa	23	18	17	18	n. 11 w.	5
Dubuque, Iowa	15	16	19	21	s. 63 w.	2
Keokuk, Iowa	20	18	15	20	n. 68 w.	5
Cairo, Ill	19	24	14	12	s. 22 e.	5
Springfield, Ill	20	20	14	19	w.	5
Hannibal, Mo. †	8	12	8	10	s. 27 w.	4
St. Louis, Mo	21	20	15	17	n. 63 w.	2
Missouri Valley.						
Columbia, Mo.*	11	10	8	9	n. 45 w.	1
Kansas City, Mo	25	20	13	15	n. 22 w.	5
Springfield, Mo	19	23	14	18	s. 45 w.	6
Lincoln, Nebr	23	17	19	14	n. 40 e.	8
Omaha, Nebr	30	12	14	15	n. 3 w.	18
Sioux City, Iowa†	13	8	5	8	n. 31 w.	6
Pierre, S. Dak	23	16	17	18	n. 8 w.	7
Huron, S. Dak	28	13	17	14	n. 11 e.	15
Yankton, S. Dak	26	12	16	20	n. 16 w.	15
Northern Slope.						
Havre, Mont	19	11	14	29	n. 62 w.	17
Miles City, Mont	15	17	14	27	s. 81 w.	13
Helena, Mont	10	15	4	41	s. 82 w.	37
Rapid City, S. Dak	27	7	12	31	n. 44 w.	28
Cheyenne, Wyo	31	11	4	23	n. 44 w.	28
Lander, Wyo	15	23	17	19	s. 14 w.	8
North Platte, Nebr	20	15	10	29	n. 75 w.	20
Middle Slope.						
Denver, Colo	24	19	15	13	n. 22 e.	5
Pueblo, Colo	24	10	20	20	n.	14
Concordia, Kans	22	17	16	14	n. 22 e.	5
Dodge City, Kans	29	17	14	16	n. 9 w.	12
Wichita, Kans	25	20	15	13	n.	5
Oklahoma, Okla	22	27	9	12	s. 31 w.	6
Southern Slope.						
Abilene, Tex	19	26	20	10	s. 55 e.	12
Amarillo, Tex	14	22	13	18	s. 32 w.	9
Southern Plateau.						
El Paso, Tex	21	6	19	29	n. 34 w.	18
Santa Fe, N. Mex	25	20	18	13	n. 45 e.	17
Phœnix, Ariz	15	8	20	24	n. 30 w.	8
Yuma, Ariz	22	11	14	21	n. 32 w.	13
Middle Plateau.						
Carson City, Nev	18	18	8	32	w.	24
Winnemucca, Nev	21	12	20	20	n.	9
Salt Lake City, Utah	18	16	18	23	n. 68 w.	5
Northern Plateau.						
Baker City, Oreg	19	28	14	12	s. 13 e.	9
Idaho Falls, Idaho	16	32	10	8	s. 7 e.	16
Spokane, Wash	9	28	15	23	s. 23 w.	21
Walla Walla, Wash	7	36	9	13	s. 8 w.	29
North Pacific Coast Region.						
Fort Canby, Wash	25	17	8	18	n. 51 w.	13
Port Angeles, Wash.*	2	1	10	19	n. 84 w.	9
Seattle, Wash	20	21	10	19	s. 84 w.	9
Tatoosh Island, Wash	10	20	18	20	s. 11 w.	10
Portland, Oreg	22	21	9	26	n. 87 w.	17
Roseburg, Oreg	26	10	13	20	n. 24 w.	18
Middle Pacific Coast Region.						
Eureka, Cal	22	15	10	30	n. 71 w.	21
Redbluff, Cal	29	20	11	15	s. 24 w.	10
Sacramento, Cal	26	22	4	22	n. 77 w.	18
San Francisco, Cal	8	11	2	45	s. 86 w.	43
South Pacific Coast Region.						
Fresno, Cal	36	2	5	35	n. 42 w.	45
Los Angeles, Cal	15	7	16	31	n. 62 w.	17
San Diego, Cal	25	6	12	33	n. 48 w.	28
San Luis Obispo, Cal	34	9	1	28	n. 47 w.	37

*From observations at 8 p. m. only. †From observations at 8 a. m. only.

TABLE IX.—*Thunderstorms and auroras, April, 1897.*

States.	No. of stations.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total. No.	Total. Days.	
Alabama	50	T.	10	1	2	1	3	2	1	4	2	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	1	7	2	...	37	14	T.
		A.	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	...	0	0	A.
Arizona	49	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	2	3	....	....	....	....	....	6	3	T.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	A.
Arkansas	50	T.	....	....	10	1	....	2	11	5	....	2	....	4	4	1	....	....	....	....	1	1	....	2	....	....	6	..	....	6	2	....	....	58	15	T.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1	3	4	1	....	....	....	....	10	5	A.
California	197	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1	9	1	4	6	2	5	1	36	13	T.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	2	....	....	1	9	1	4	6	2	5	1	....	0	0	A.
Colorado	71	T.	....	....	....	....	2	....	1	....	1	....	....	....	....	....	....	....	....	....	1	2	....	....	1	9	1	4	6	2	5	1	....	36	13	T.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	A.
Connecticut	14	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	A.
		A.	3	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Delaware	4	T.	....	....	....	....	2	....	....	....	1	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4	2	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4	3	T.
Dist. of Columbia	4	T.	....	....	....	....	1	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1	1	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	2	T.
Florida	38	T.	5	3	1	3	5	6	1	3	9	2	....	....	....	....	3	1	....	1	7	1	....	....	....	....	....	1	....	1	4	11	..	0	0	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	68	19	T.
Georgia	50	T.	3	....	....	5	6	2	1	7	1	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	2	....	....	7	15	....	0	0	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	50	11	T.
Idaho	36	T.	....	....	....	1	....	....	....	....	....	4	....	....	....	....	....	....	....	2	1	1	....	....	....	....	....	1	....	....	....	....	....	0	0	A.
		A.	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10	6	T.
Illinois	97	T.	5	....	7	7	....	....	2	4	..	....	....	8	7	....	1	....	2	17	2	1	2	17	28	25	3	1	....	8	8	....	....	1	1	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	1	....	....	....	4	....	1	....	....	....	....	....	....	....	155	20	T.
Indiana	49	T.	....	....	....	2	....	....	....	1	1	....	....	....	5	....	....	....	....	....	....	....	....	3	15	5	2	....	....	....	8	....	....	7	4	A.
		A.	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	42	9	T.
Indian Territory	7	T.	....	....	4	....	....	....	....	1	....	....	....	....	2	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	1	1	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	....	....	....	....	10	5	T.
Iowa	101	T.	1	....	6	1	....	....	....	....	....	1	1	13	3	....	2	1	....	2	1	6	20	25	30	10	1	....	..	....	....	....	....	0	0	A.
		A.	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	114	17	T.
Kansas	73	T.	1	4	3	....	....	1	2	1	1	....	....	1	....	....	1	....	....	5	....	2	3	8	12	17	3	....	6	9	....	....	....	1	1	A.
		A.	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....	....	....	....	80	19	T.
Kentucky	47	T.	1	....	2	2	....	....	....	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3	1	....	....	8	5	....	4	4	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	31	8	T.
Louisiana	51	T.	2	4	17	3	6	15	6	12	4	2	1	....	2	6	1	....	....	....	....	....	....	4	....	....	5	1	....	4	10	....	....	0	0	A.
		A.	....	....	....	..	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	105	19	T.
Maine	13	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	A.
		A.	4	....	1	2	1	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Maryland	31	T.	....	....	....	....	9	....	....	2	2	....	....	....	....	2	....	....	2	....	....	....	....	....	....	....	....	1	....	1	....	....	....	12	8	A.
		A.	....	....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17	5	T.
Massachusetts	27	T.	....	....	....	....	....	1	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	1	....	....	....	1	....	....	....	....	4	4	A.
		A.	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	2	2	T.
Michigan	96	T.	....	....	....	6	....	....	....	....	....	....	....	....	6	....	....	....	....	7	....	1	1	2	27	21	1	....	....	....	1	....	....	7	2	A.
		A.	12	2	1	1	..	2	2	....	1	....	....	....	....	....	....	....	....	....	....	1	1	....	4	2	....	....	....	....	....	....	....	73	9	T.
Minnesota	69	T.	1	....	1	....	....	....	....	....	1	....	....	....	....	....	....	....	....	1	....	....	13	1	1	....	....	4	3	....	....	....	....	27	9	A.
		A.	3	1	....	....	2	....	....	....	1	....	....	1	1	..	1	....	....	....	....	4	....	3	1	2	....	....	2	1	....	....	....	26	9	T.
Mississippi	45	T.	3	....	6	....	4	3	....	9	....	1	....	....	....	3	1	....	....	....	....	....	....	....	....	....	1	....	....	3	3	....	....	23	13	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	37	11	T.
Missouri	96	T.	7	....	20	....	1	....	15	8	3	2	..	6	2	....	3	....	....	12	2	2	5	14	15	16	11	2	3	24	2	1	....	176	23	A.
		A.	....	....	....	....	....	....	....	1	....	1	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	T.
Montana	40	T.	....	....	....	....	....	....	....	....	....	1	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5	4	T.
Nebraska	112	T.	2	2	6	2	....	1	1	1	....	....	1	2	....	3	1	....	....	....	....	5	15	7	10	1	....	....	2	1	....	....	....	63	18	A.
		A.	....	....	....	....	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....	....	....	....	6	4	T.
Nevada	39	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	....	....	....	....	....	....	....	4	1	....	1	....	7	3	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
New Hampshire	23	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	A.
		A.	5	....	3	....	5	....	....	....	1	....	....	....	....	....	....	....	....	....	1	2	....	....	....	....	....	....	....	2	....	....	....	18	6	T.
New Jersey	54	T.	....	....	....	....	17	7	1	4	7	....	....	....	....	6	5	....	....	....	....	1	....	....	....	....	....	2	....	....	....	....	....	50	9	A.
		A.	2	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	1	....	....	3	10	6	1	1	2	....	3	2	T.
New Mexico	42	T.	....	....	....	....	....	..	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	25	8	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
New York	93	T.	....	....	....	....	19	1	1	....	....	....	....	....	....	1	....	....	1	....	....	....	....	....	9	2	3	....	1	....	....	....	....	38	9	A.
		A.	16	2	2	....	3	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	26	7	T.
North Carolina	60	T.	2	....	...	3	11	3	....	16	13	2	...	....	....	....	1	2	....	....	....	....	....	1	....	....	1	1	....	....	6	14	....	75	13	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
North Dakota	39	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	A.
		A.	10	....	....	1	1	2	1	....	1	....	....	....	2	1	1	1	....	....	1	2	1	1	4	1	....	....	1	....	....	....	....	35	20	T.
Ohio	140	T.	....	....	....	1	6	....	....	....	....	..	..	....	14	....	....	....	....	....	1	....	1	....	11	10	5	10	....	1	1	1	....	1	71	10	A.
		A.	6	1	1	....	....	....	1	....	....	1	1	....	....	....	....	....	....	....	....	1	....	1	2	2	....	2	....	6	1	....	4	9	....	18	10	T.
Oklahoma	20	T.	....	....	2	....	....	1	2	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6	2	....	....	....	....	....	....	21	8	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Oregon	60	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	1	....	....	....	....	....	1	....	....	....	....	....	3	3	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Pennsylvania	93	T.	....	..	....	2	27	2	....	....	3	....	....	....	....	2	1	....	....	....	....	....	....	1	1	1	4	2	....	1	....	1	....	48	13	A.
		A.	6	....	....	....	1	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8	3	T.
Rhode Island	6	T.	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
South Carolina	42	T.	2	....	....	5	11	1	....	5	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7	....	....	7	14	....	....	58	9	A.
		A.	..	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	2	3	....	....	2	....	....	6	1	....	....	....	....	....	15	6	T.
South Dakota	46	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	A.
		A.	....	....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7	4	T.
Tennessee	49	T.	4	....	10	5	7	1	1	19	2	....	....	....	3	4	....	1	....	....	....	....	....	1	....	2	5	1	....	....	13	7	....	83	15	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Texas	91	T.	....	1	6	1	2	3	1	6	....	1	....	1	7	5	....	1	....	....	....	....	....	....	....	2	4	1	4	10	....	1	....	57	18	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Utah	32	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	....	....	....	1	....	3	2	2	....	2	....	....	12	6	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	1	T.
Vermont	13	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	....	....	....	....	....	....	1	1	A.
		A.	5	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	1	....	....	....	....	9	5	T.
Virginia	37	T.	....	....	....	....	9	....	....	9	1	....	....	....	2	....	5	....	....	....	....	....	....	....	....	....	....	....	....	....	5	....	....	31	6	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Washington	51	T.	....	....	....	1	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	2	A.
		A.	3	....	....	....	4	....	....	1	1	....	....	....	....	1	1	....	1	....	....	....	....	1	3	2	....	....	....	....	....	1	....	15	10	T.
West Virginia	37	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	....	....	....	3	....	....	9	3	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Wisconsin	58	T.	1	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	1	....	....	2	8	9	7	....	....	....	4	....	....	....	....	33	8	A.
		A.	2	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1	4	4	....	1	....	....	....	....	....	....	....	13	6	T.
Wyoming	11	T.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3	1	....	....	....	....	....	....	....	....	....	....	....	4	2	A.
		A.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0	T.
Sums	2,644	T.	50	15	103	52	152	52	47	127	58	20	3	36	55	39	22	10	6	49	19	31	66	105	159	132	75	50	54	82	96	94	....	1,859	....	T.
		A.	86	8	10	5	19	5	4	1	4	1	1	2	3	3	2	6	1	0	5	7	8	8	30	11	5	6	6	8	0	2	....	257	....	A.

TABLE X.—*Hourly sunshine as deduced from sunshine recorders, April, 1897.*

Stations.	Instrument.	Percentages for each hour of local mean time ending with the respective hour.																Hours of sunshine.			
		A. M.								P. M.								Total.			
		5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	Actual.	Possible.	Per cent of possible.	Personal estimate.
																		Hours.	*Hours.*		
Albany, N. Y	T.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38
Atlanta, Ga	T.	.....	54	52	57	60	57	59	65	63	65	65	61	56	51	52	.....	230.4	391.6	59	54
Atlantic City, N. J	P.	.....	72	70	67	72	82	84	79	74	71	71	68	66	50	48	.....	278.6	397.0	70	57
Baltimore, Md	T.	.....	49	47	46	55	61	67	70	66	62	59	56	47	33	33	.....	215.3	397.0	54	55
Binghamton, N. Y	T.	29	30	38	41	45	54	63	60	63	59	52	43	36	37	36	.....	190.9	401.1	48	42
Bismarck, N. Dak	P.	45	42	42	44	45	44	53	52	48	45	42	46	48	40	36	43	183.8	408.4	45	41
Boston, Mass	T.	71	46	61	61	62	64	65	64	58	54	56	52	53	51	38	.....	227.4	401.1	57	50
Buffalo, N. Y. *	T.	.....	30	45	50	61	73	77	77	81	85	69	61	46	33	19	.....	205.0	346.1	59	30
Charleston, S. C	T.	.....	43	38	52	70	77	85	85	87	82	76	70	64	67	67	.....	272.6	390.5	70	61
Chattanooga, Tenn	T.	.....	52	46	47	55	58	65	70	62	65	58	52	49	35	34	.....	212.7	392.7	54	47
Cheyenne, Wyo	P.	.....	31	51	64	71	70	70	66	66	66	62	59	60	52	41	.....	241.0	399.4	60	52
Chicago, Ill	T.	0	28	31	36	48	55	59	64	67	67	65	60	45	27	19	.....	196.1	401.1	49	46
Cincinnati, Ohio	T.	.....	44	40	45	49	54	52	54	59	62	58	55	47	28	26	.....	193.5	397.0	49	44
Cleveland, Ohio	T.	0	6	8	25	38	44	48	47	59	50	38	26	23	14	14	.....	129.9	401.1	32	26
Columbus, Ohio†	T.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30
Denver, Colo	P.	.....	54	64	77	88	88	85	78	68	67	71	69	47	49	37	.....	275.2	398.6	69	51
Des Moines, Iowa	T.	71	42	41	42	43	47	55	52	48	46	54	44	46	46	46	.....	187.5	401.1	47	44
Detroit, Mich	T.	0	24	27	40	52	52	59	54	53	51	41	36	27	25	24	.....	164.5	401.1	41	33
Dodge City, Kans	P.	.....	58	65	70	71	75	72	72	66	67	63	68	62	58	37	.....	260.2	396.2	66	57
Dubuque, Iowa	T.	0	35	31	38	48	48	52	50	56	54	52	46	42	35	38	.....	180.1	401.1	44	49
Eastport, Me	P.	0	22	34	39	40	50	49	46	49	55	54	58	52	43	31	0	182.7	405.2	45	37
Erie, Pa	T.	0	30	31	36	49	54	59	58	55	59	60	55	40	27	19	.....	184.3	401.1	46	40
Eureka, Cal	P.	.....	21	35	47	56	58	65	72	72	74	69	65	63	66	54	.....	238.0	399.4	60	51
Fresno, Cal	T.	.....	92	87	86	93	95	94	95	98	98	99	97	90	88	88	.....	367.3	394.8	93	88
Galveston, Tex	P.	.....	32	44	67	76	90	88	89	76	81	76	81	72	58	25	.....	277.1	386.4	72	64
Helena, Mont	P.	64	54	53	59	63	62	61	61	58	60	61	61	52	51	58	71	237.5	408.4	58	54
Idaho Falls, Idaho	T.	100	53	43	45	69	75	83	82	80	74	70	61	58	54	49	.....	257.7	402.1	64	72
Indianapolis, Ind	T.	.....	33	29	41	48	62	55	64	67	65	64	55	44	35	32	.....	200.4	398.6	50	39
Kansas City, Mo	P.	.....	38	35	43	49	51	52	56	54	57	50	52	49	38	43	.....	190.9	397.0	48	40
Little Rock, Ark	T.	.....	44	49	50	54	72	78	82	86	86	78	70	67	61	48	.....	265.5	392.7	68	47
Los Angeles, Cal	P.	.....	55	63	71	68	76	80	84	86	94	94	93	89	85	63	.....	314.1	391.6	80	69
Louisville, Ky	T.	.....	43	35	41	55	60	66	69	71	69	68	57	51	37	38	.....	218.4	396.2	55	40
Minneapolis, Minn	T.	40	38	30	29	37	45	57	57	59	50	42	36	18	13	16	50	153.9	405.2	38	.....
Nashville, Tenn	T.	.....	55	53	57	58	56	59	61	64	66	63	64	63	61	48	.....	235.3	393.6	60	54
New Orleans, La	T.	.....	24	21	19	19	33	42	53	51	44	45	34	22	17	16	.....	125.6	387.4	32	32
New York, N. Y	T.	.....	41	60	74	80	85	93	96	84	82	81	86	80	64	37	.....	304.6	399.4	76	58
Northfield, Vt	P.	3	32	37	48	45	50	49	52	54	50	52	53	47	37	27	100	184.7	403.6	46	35
Omaha, Nebr	P.	.....	46	36	49	50	49	52	54	51	56	56	60	47	42	41	.....	197.8	399.4	50	41
Philadelphia, Pa	T.	.....	60	62	67	75	76	78	80	77	78	73	67	67	68	72	.....	285.7	398.6	72	51
Phœnix, Ariz	P.	.....	87	96	100	96	96	99	99	98	95	98	94	91	91	80	.....	371.3	390.5	95	89
Pittsburg, Pa	T.	.....	27	28	33	39	46	53	57	61	59	56	46	39	25	26	.....	172.7	399.4	43	38
Portland, Me	T.	0	30	46	57	64	70	73	81	78	81	71	64	58	53	38	25	253.9	403.6	63	49
Portland, Oreg	T.	25	36	33	40	55	67	76	73	73	74	73	68	60	61	67	50	250.4	407.0	61	60
Do	P.	25	36	39	53	57	70	79	69	68	75	78	75	74	64	67	50	264.5	407.0	65	60
Raleigh, N. C	T.	.....	55	51	69	77	77	82	89	91	92	88	81	74	61	53	.....	297.9	393.6	76	57
Rochester, N. Y	T.	14	35	40	48	53	55	61	58	48	52	50	47	43	27	24	.....	187.0	402.1	47	44
St. Louis, Mo	T.	.....	35	38	49	59	67	64	61	62	58	59	47	41	37	40	.....	306.1	397.0	52	38
St. Paul, Minn	P.	60	41	45	57	60	61	61	57	61	62	59	51	50	41	32	90	216.1	405.2	53	46
Salt Lake City, Utah	P.	.....	66	58	65	74	72	74	70	66	74	72	63	61	59	53	.....	265.9	399.4	67	50
San Diego, Cal	P.	.....	41	47	52	64	78	87	88	87	92	90	90	86	78	66	.....	298.2	390.5	76	75
San Francisco, Cal	T.	.....	55	58	70	79	89	98	93	94	96	93	91	83	67	48	.....	330.9	396.2	81	70
Santa Fe, N. Mex	P.	.....	58	74	83	90	86	86	75	72	68	70	65	71	64	35	.....	287.2	393.6	73	62
Savannah, Ga	P.	.....	47	41	51	61	68	70	64	64	65	66	68	69	51	49	.....	236.1	389.9	61	53
Seattle, Wash	T.	14	30	33	44	57	64	67	69	72	81	75	67	53	39	34	20	232.4	410.4	57	57
Spokane, Wash.†	P.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	43
Tampa, Fla	T.	.....	65	52	47	40	56	61	62	67	66	61	52	35	43	47	.....	206.7	385.4	54	50
Vicksburg, Miss	T.	.....	61	60	80	84	85	86	86	77	86	88	87	76	61	49	.....	303.1	389.9	78	75
Washington, D. C	P.	.....	57	59	69	70	67	69	72	75	74	73	68	69	59	49	.....	266.8	397.0	67	60
Wilmington, N. C	T.	.....	37	42	54	75	84	85	87	85	84	84	67	62	52	44	.....	271.4	391.6	69	62

* All values are for 26 days; the total possible and personal estimate for 30 days are 402.1 and 33 respectively. † Instrument out of order.

TABLE XI.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.75 in 1 hour during April, 1897, at all stations furnished with self-registering gauges.*

Station.	Date.	Total duration.		Total amt. of precipitation.	Excessive rate.		Amount before excessive began.	Depths of precipitation (in inches) during periods of time as indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
	1	2	3	4	5	6	7														
Atlanta, Ga.*																					
Baltimore, Md.	8-9			1.23														0.41			
Binghamton, N. Y.	8-9			0.76														0.11			
Bismarck, N. Dak.	3-4			0.86														0.11			
Boston, Mass.	8-9			1.65														0.21			
Buffalo, N. Y.	13			0.84														0.33			
Chicago, Ill.*																					
Cincinnati, Ohio	3-4			0.49														0.23			
Cleveland, Ohio†	8-9			0.44														0.06			
Denver, Colo.	29			0.48														0.23			
Des Moines, Iowa	22-23	8.05 p.m.	8.35 a.m.	2.95	8.38 p.m.	9.00 p.m.	0.05	0.08	0.18	0.32	0.41										
					10.05 p.m.	11.05 p.m.	0.48	0.13	0.43	0.73	0.88	0.96	1.07	1.17	1.24	1.31	1.33	1.41	1.50	1.53	1.57
Detroit, Mich.	23			0.39														0.31			
Dodge City, Kans.*																					
Duluth, Minn.	27-28			0.29														0.16			
Eastport, Me.	17	3.10 p.m.	7.30 p.m.	0.63	5.03 p.m.	5.25 p.m.	0.05	0.05	0.20	0.32	0.42	0.45									
Erie, Pa.	8-9			0.57																	
Galveston, Tex.	14	6.02 a.m.	9.07 a.m.	0.78	7.07 a.m.	7.25 a.m.	0.02	0.37	0.46	0.49	0.54	0.56	0.58	0.59	0.61						
Harrisburg, Pa.	8-9			1.13														0.14			
Hatteras, N. C.	15			0.37														0.35			
Indianapolis, Ind.	29			0.52														0.46			
Jacksonville, Fla.	9	3.30 a.m.	11.30 a.m.	1.75	3.30 a.m.	3.45 a.m.	0.00	0.32	0.50	0.55	0.58	0.61	0.63	0.64	0.65	0.67	0.69	0.70	0.74	0.79	0.85
Jupiter, Fla.	7	12.55 p.m.	2.15 p.m.	0.74	1.09 p.m.	1.17 p.m.	0.05	0.30	0.40	0.41	0.42	0.43	0.44	0.45	0.53	0.64	0.71	0.72			
Do	15	2.10 p.m.	3.30 p.m.	0.77	2.22 p.m.	2.37 p.m.	0.05	0.30	0.47	0.65	0.70	0.72	0.73								
Do	30	7.30 a.m.	5.05 p.m.	4.25	10.03 a.m.	†	0.10	0.42	0.55	0.68	0.78	†	†	†	†	†	†	†	†	†	2.46
Kansas City, Mo.	24			0.79														0.56			
Key West, Fla.	6	11.06 p.m.	11.55 p.m.	0.95	11.33 p.m.	11.50 p.m.	0.05	0.45	0.70	0.85	0.88	0.92	0.93	0.94	0.95						
Lincoln, Nebr.	23-24	5.50 p.m.	3.45 a.m.	2.13	7.27 p.m.	7.47 p.m.	0.37	0.18	0.48	0.78	1.08	1.12									
Little Rock, Ark.	28	8.43 p.m.	9.30 p.m.	0.39	9.05 p.m.	9.15 p.m.	0.02	0.10	0.32	0.37											
Louisville, Ky.	25			0.41														0.33			
Memphis, Tenn.*																					
Milwaukee, Wis.	24			0.56														0.45			
Montgomery, Ala.	29	9.45 a.m.	12.35 p.m.	1.35	10.13 a.m.	10.30 a.m.	0.01	0.25	0.56	0.87	0.95	1.00	1.03	1.07	1.10	1.13	1.16	1.22			
Nantucket, Mass.	9			1.23														0.60			
Nashville, Tenn.	4			1.42														0.65			
New Orleans, La.	6	6.40 p.m.	8.05 p.m.	1.09	6.47 p.m.	7.20 p.m.	0.01	0.30	0.29	0.39	0.63	0.80	0.86	0.89	0.92	0.96	0.97	0.98			
Do	8	6.05 p.m.	8.05 p.m.	0.78	6.18 p.m.	6.53 p.m.	0.02	0.09	0.39	0.58	0.59	0.63	0.74	0.76							
New York, N. Y.	17			0.50														0.20			
Norfolk, Va.	5			0.15														0.15			
Omaha, Nebr.	22-23	9.30 p.m.	6.50 a.m.	1.05	9.38 p.m.	10.05 p.m.	T.	0.12	0.28	0.35	0.44	0.46	0.47	0.48							
Philadelphia, Pa.	8-9			1.36														0.32			
Pittsburg, Pa.	26	2.10 p.m.	2.40 p.m.	0.43	2.18 p.m.	2.30 p.m.	0.01	0.19	0.37	0.40	0.42										
Portland, Me.	15			0.35														0.19			
Portland, Oreg.	19			0.75														0.12			
Raleigh, N. C.	9	6.20 a.m.	5.15 p.m.	2.10	6.35 a.m.	7.15 a.m.	0.03	0.10	0.35	0.44	0.60	0.75	0.82	0.85	0.91	0.94	0.96	1.00	1.06	1.15	1.23
Rochester, N. Y.	5			0.18														0.12			
St Louis, Mo.	1			1.44														0.48			
St. Paul, Minn.	21			0.17									0.17								
Salt Lake City, Utah.	20-21			0.99														0.25			
San Diego, Cal.	26			0.02														0.02			
San Francisco, Cal.	6			0.03														0.03			
Savannah, Ga.	26	2.50 p.m.	3.15 p.m.	0.27	2.58 p.m.	3.02 p.m.	T.	0.26													
Tampa, Fla.	29-30	10.30 p.m.	3.25 a.m.	1.72	12.48 a.m.	1.12 a.m.	25	0.09	0.35	0.55	0.80	0.96	0.99	1.01	1.03	1.05	1.06	1.11			
Vicksburg, Miss.	3	7.00 a.m.	7.45 a.m.	0.51	7.11 a.m.	7.27 a.m.	1	0.19	0.34	0.48	0.49										
Washington, D. C.	8-9			1.10														0.54			
Wilmington, N. C.	‡	5.05 p.m.	9.30 a.m.	1.71	5.15 p.m.	5.35 p.m.		0.15	0.36	0.40	0.50	0.54	0.56								

*Self register out of order. †Self register out of order after 10.25 a. m.; 2.46 inches fell from 10.00 a. m. to 12.00 noon, and estimated that 1.00 inch fell from 12.00 noon to 1.00 p. m., making a total fall of 3.46 inches in three hours. ‡April 30 to May 1.

TABLE XII.—*Excessive precipitation, by stations, for April, 1897.*

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
Alabama.	*Inches.*	*Inches.*		*Ins.*	*h.m.*	
Mobile		2.59	3-4			
Montgomery		2.51	29-30	1.22	1 00	29
Mount Willing		2.75	29			
Rockmills		3.03	29-30			
Arkansas.						
Silver Springs		2.59	24-25			
California.						
Redding		2.51	19			
Florida.						
Archer		3.33	9			
Federal Point		2.82	12			
Jupiter		4.25	30	3.45	2 56	30
Lake Butler		3.45	9-10			
Lemon City	10.55	6.60	15			
Do		2.65	18			
Milton		3.30	1			
Do		2.00	8-9			
St. Francis Barracks		2.70	8			
Tallahassee		4.01	4			
Do		3.47	9			
Tampa				1.40	0 30	9
Do				1.00	0 30	30
Georgia.						
Clayton	11.65	2.90	1			
Do		5.02	4			
Columbus		2.61	1-2			
Dahlonega		2.88	4			
Piscola		2.95	9			
Illinois.						
Beardstown		2.63	1-2			
Indiana.						
Mount Vernon		2.50	1			
Princeton		2.80	8-9			
Indian Territory.						
Eufaula		5.60	24-25			
South McAlester		2.50	28			
Tahlequah		4.20	24-25			
Tulsa		2.80	28			
Iowa.						
Afton		6.12	23-24			
Centerville		3.10	1			
Do		2.50	23			
Chariton		2.85	22-23			
Clarinda		3.90	23-24			
College Springs		3.00	24			
Corning		4.00	24			
Des Moines		2.95	22-23	1.41	1 00	22
Gardengrove		3.76	24			
Grinnell		2.50	22			
Hopeville		7.00	23-24			
Knoxville		2.95	24			
Lenox		2.89	24			
Millman		2.84	23			
Mountayr		4.55	23-24			
Osceola		6.30	23-24			
Oskaloosa		2.75	24			
Ovid		3.24	24			
Villisca		3.71	23-24			
Waukee		4.18	23			
Winterset		3.08	1			
Kansas.						
Atchison		3.20	24			
Baker		2.80	23			
Elgin		3.00	27			
Grenola		2.52	27			
Manhattan		2.71	24			
Morton		2.67	23-24			
Oberlin		2.75	11-12			
Sedan		2.73	27			
Kentucky.						
Canton		2.60	25			
Eubank		2.96	4			
Marrowbone		2.58	3-4			
Middlesboro		3.75	3-4			
Paducah		3.80	*			
Russellville		2.73	8			
Southfork		2.60	4-5			
Williamsburg		3.26	3-4			
Louisiana.						
Abbeville	12.40	9.40	2-3			
Covington		2.71	3			
Donaldsonville	11.08	4.00	3			
Do		3.10	29			
Elm Hall		2.50	3			
Emilie		2.75	2-3			
Franklin		5.23	3-4			
Hammond		3.20	2-3			
Houma	10.64	6.01	2-3			
Jeanerette		4.50	2-3			
Lawrence		3.80	3			
New Iberia		3.05	3			
Do		3.75	14			
Oberlin				1.40	1 00	28
Paincourtville	10.28	4.82	2-3			
Port Eads	11.70	9.30	3			
Shellbeach		3.75	2			
Thibodeaux		6.00	3			
Wallace		3.45	2-3			
Maryland.						
Marbela Springs		2.76	8-9			

TABLE XII.—*Excessive precipitation*—Continued.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
Massachusetts.	*Inches.*	*Inches.*		*Ins.*	*h.m.*	
Hyannis		2.97	9			
New Bedford		2.68	9-10			
Vineyard Haven		3.00	8-9			
Woods Hole		3.06	8-9			
Mississippi.						
Bay St. Louis		4.97	1			
Biloxi		2.65	3			
Logtown				1.04	1 00	8
Waynesboro				1.10	0 40	29
Missouri.						
Columbia				0.99	0 18	28
Irena		2.73	24			
Mineralspring		3.00	7-8			
Oregon		2.60	23-24			
Platte River		2.65	23			
St. Louis (V. O)		2.79	1			
Sikeston		2.74	8			
Sublett		3.50	22-23			
Nebraska.						
Ashton		2.78	2			
Brokenbow		2.50	11-12			
Burchard		4.45	24			
Callaway		3.25	11-12			
Curtis		2.50	11			
Elba		2.66	3			
Ericson		2.79	3-4			
Greeley Center		3.00	3			
Kearney		2.50	3			
Lincoln (W. B.)				1.20	1 00	23
Loup		2.58	2-3			
Lynch		3.97	2-3			
Minden		2.52	3			
North Loup		2.95	2			
Rulo		2.82	23			
St. Paul		2.93	3			
Wilber		4.45	23-24			
New Jersey.						
Hammonton		2.66	8-9			
North Carolina.						
Flatrock		3.74	4			
Lynn	10.57	5.90	4			
Marion		2.74	4			
Morganton		2.71	4			
Raleigh				1.00	1 00	9
Oklahoma.						
Arapaho		3.32	27			
Beaver		4.60	23-24	1.00	0 20	27
Clifton		4.45	24-25			
Edmond	13.35	7.30	24-25			
Do		4.70	27			
Fort Reno		2.95	24-25			
Do		4.12	27-28			
Hennessey		2.62	27			
Keokuk Falls		3.65	24			
Kingfisher		4.13	27			
Oklahoma		2.79	24-25			
Ponca		6.38	27-28			
Pondcreek		3.06	24			
Prudence		3.10	27			
Sac and Fox Agency		3.00	24-25			
Do		2.80	27			
Stillwater		3.87	27			
Winnview		3.50	27			
Rhode Island.						
Block Island		3.73	8-9			
Kingston		2.63	9			
South Carolina.						
Georgetown		3.20	30			
Greenville		2.52	4-5			
Society Hill		3.50	8			
Walhalla		3.00	3-4			
South Dakota.						
Armour		2.50	3			
Greenwood		3.57	3			
Tennessee.						
Andersonville		3.45	3-4			
Decatur		3.97	3-4			
Elk Valley		3.65	3-4			
Erasmus		2.89	3-4			
Harriman		4.88	3-4			
Lynnville		2.80	3-4	1.00	0 15	8
Molino		2.77	3-4			
Oak Hill		2.59	3-4			
Palmetto		3.57	3-4			
Rockwood		3.62	3-4			
Rugby		3.78	3-4			
Tellico Plains		2.71	*			
Tullahoma		3.00	3-4			
Texas.						
Fredericksburg				1.04	0 30	13
Luling				1.02	0 50	8
New Braunfels				1.04	1 00	8
San Antonio				1.20	0 50	14
Tyler				2.00	2 00	25
Washington.						
Tatoosh Island		2.78	28-29			
Wisconsin						
Gratiot		4.25	24			

† March 31 to April 1.

Chart I. Tracks of Centers of High Areas. April, 1897.

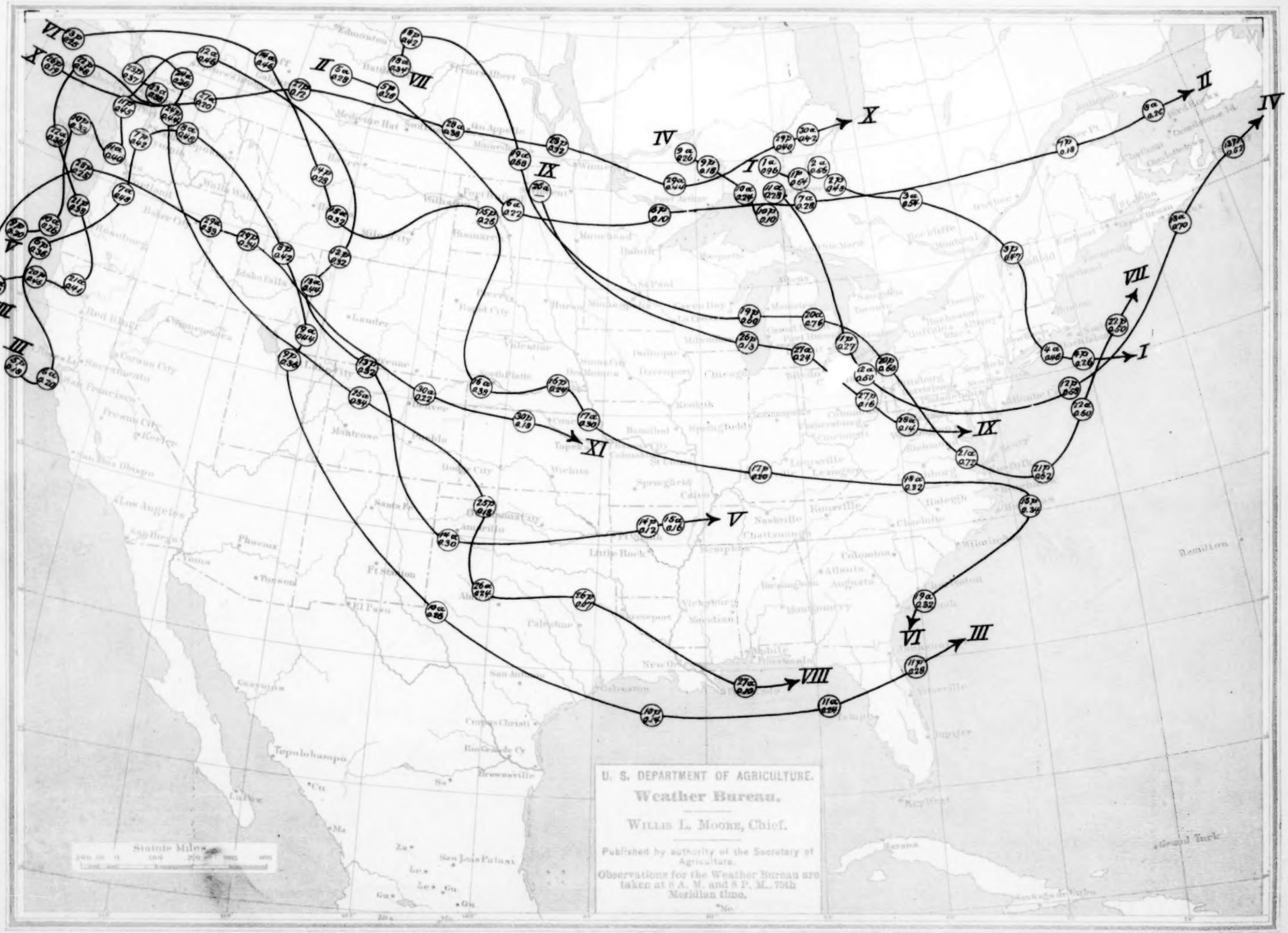

U. S. DEPARTMENT OF AGRICULTURE.
Weather Bureau.
WILLIS L. MOORE, Chief.
Published by authority of the Secretary of Agriculture.
Observations for the Weather Bureau are taken at 8 A. M. and 8 P. M., 75th Meridian time.
Statute Miles

Chart II. Tracks of Centers of Low Areas. April, 1897.

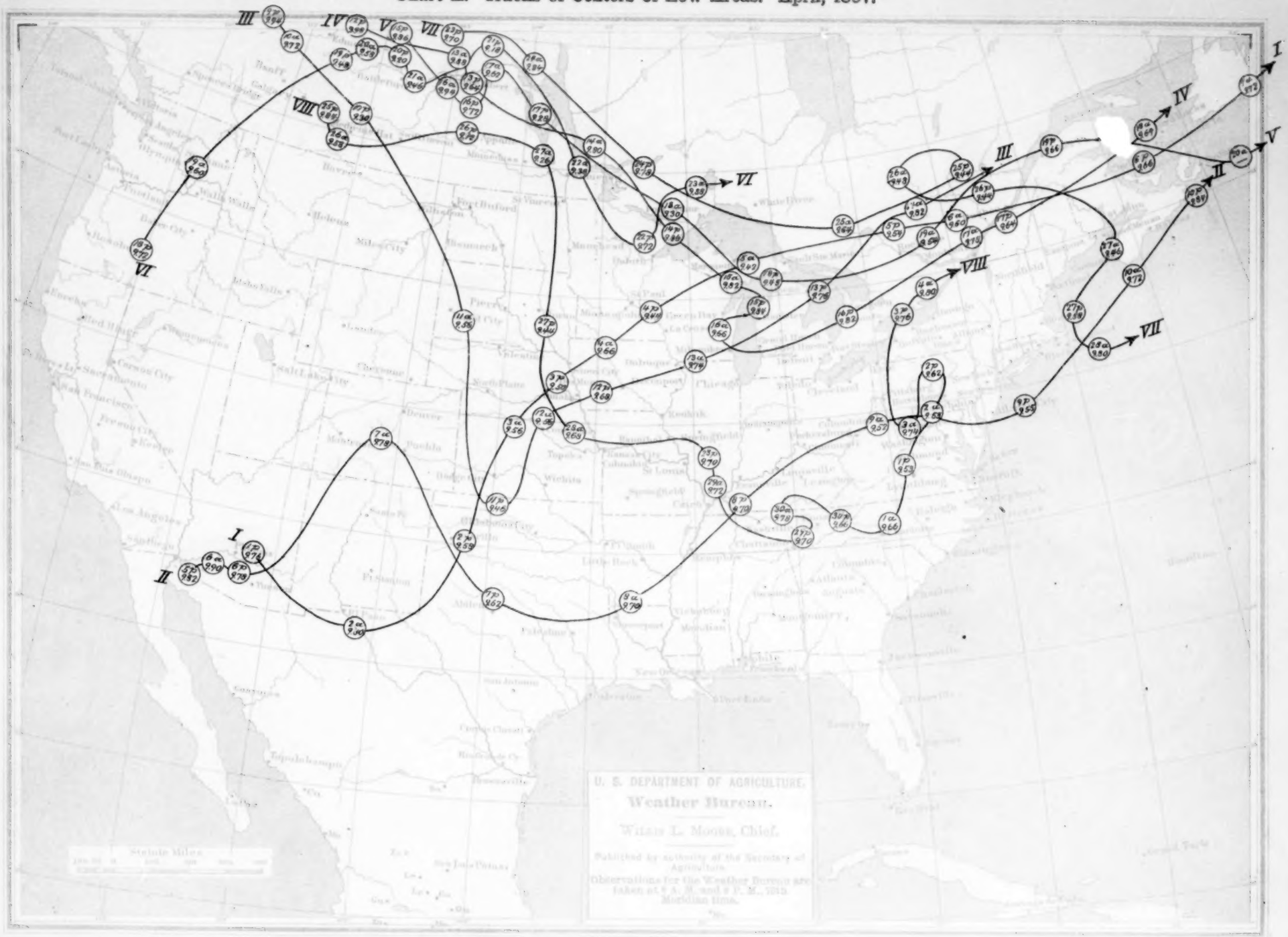

U. S. DEPARTMENT OF AGRICULTURE.
Weather Bureau.
Willis L. Moore, Chief.
Published by authority of the Secretary of Agriculture.
Observations for the Weather Bureau are taken at 8 A. M. and 8 P. M., 90th Meridian time.
Statute Miles

Chart III. Total Precipitation. April, 1897.

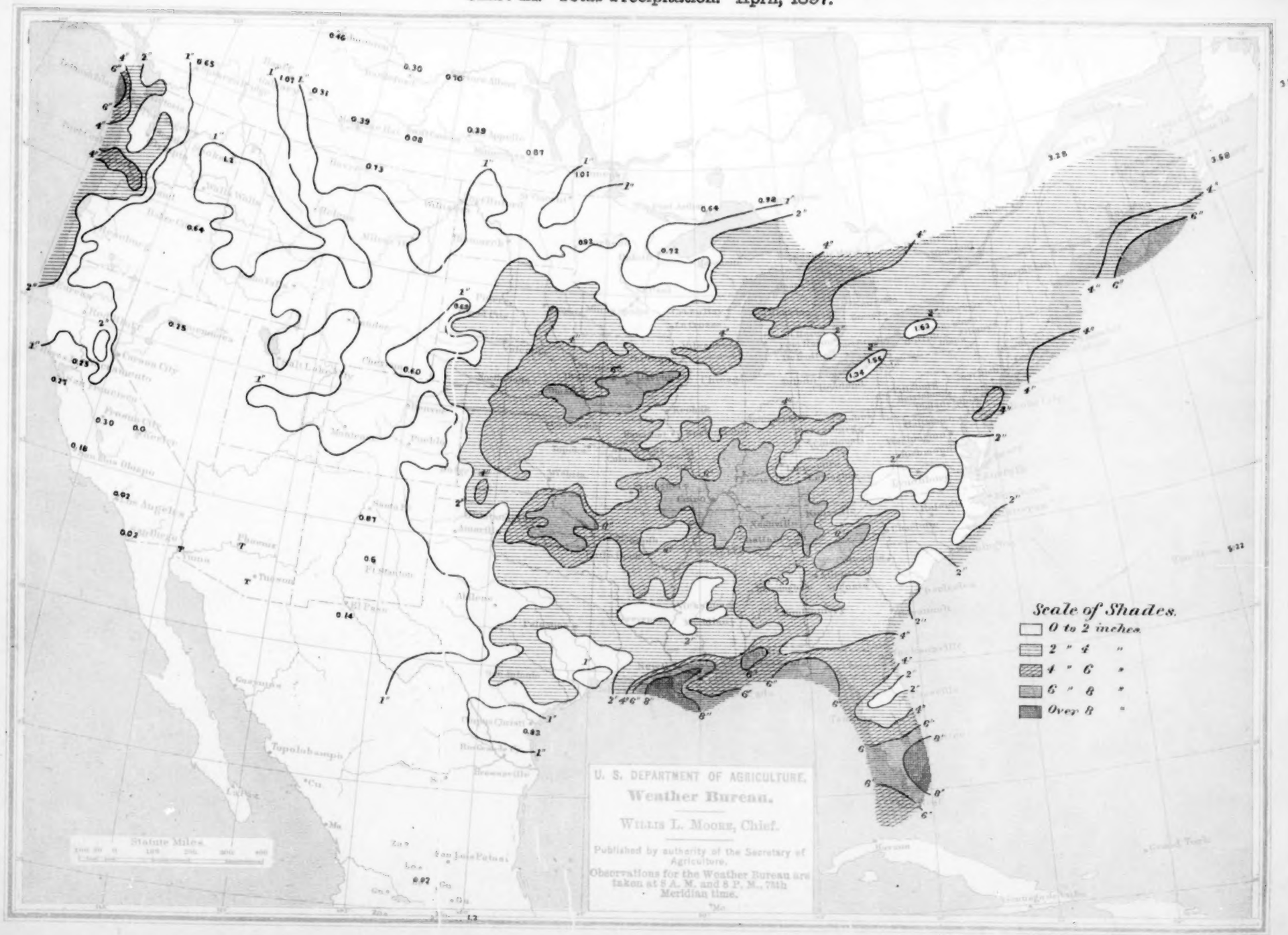
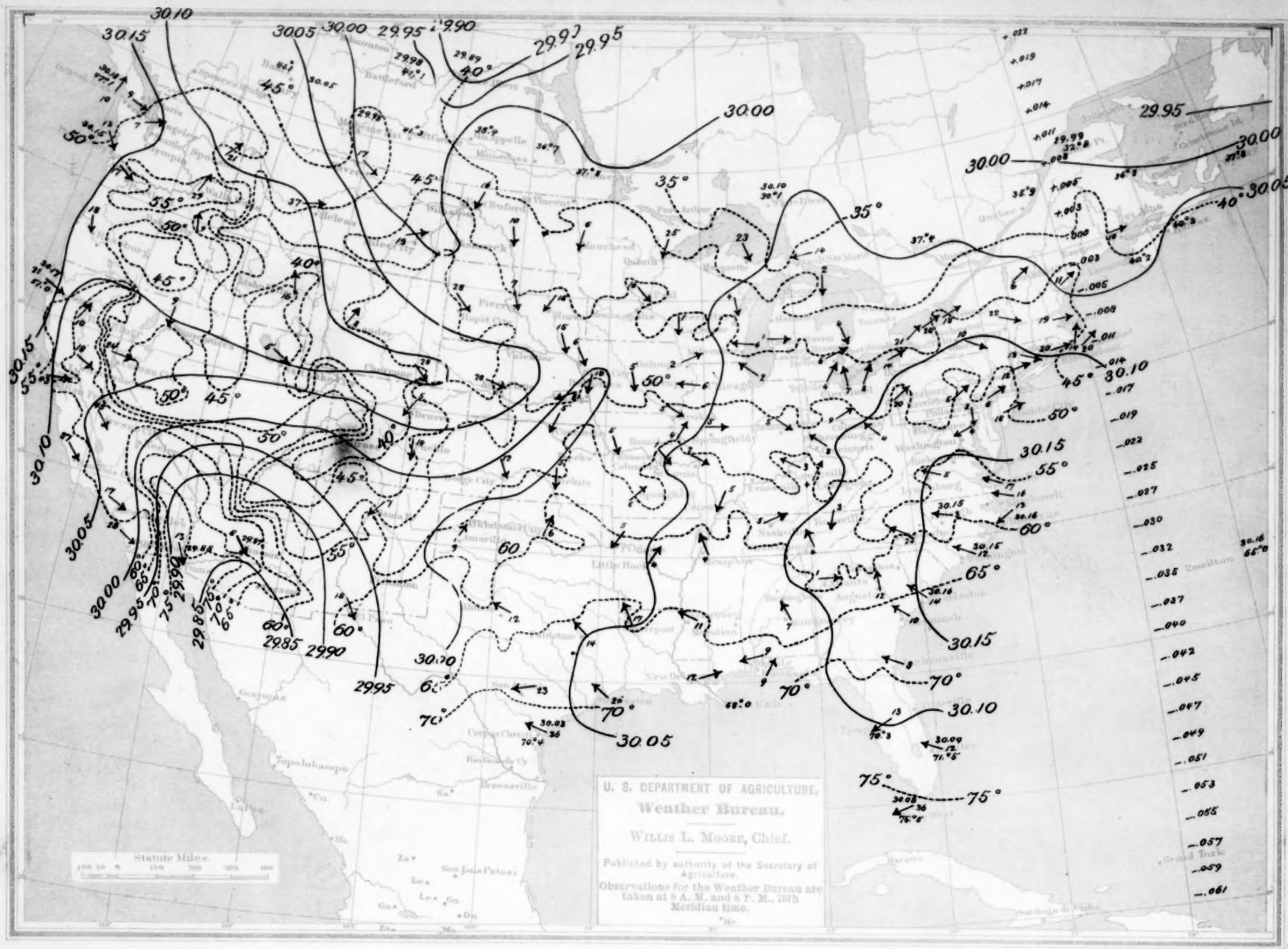

Scale of Shades.
0 to 2 inches.
2 " 4 "
4 " 6 "
6 " 8 "
Over 8 "
U. S. DEPARTMENT OF AGRICULTURE.
Weather Bureau.
Willis L. Moore, Chief.
Published by authority of the Secretary of Agriculture.
Observations for the Weather Bureau are taken at 8 A. M. and 8 P. M., 75th Meridian time.
Statute Miles

Chart IV. Isobars, Isotherms, and Resultant Winds. April, 1897.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Weather Bureau.
WILLIS L. MOORE, Chief.
Published by authority of the Secretary of Agriculture.
Observations for the Weather Bureau are taken at 8 A. M. and 8 P. M., 75th Meridian time.
Statute Miles

Chart V. Depth of Snowfall and Limits of Freezing Weather. April, 1897.

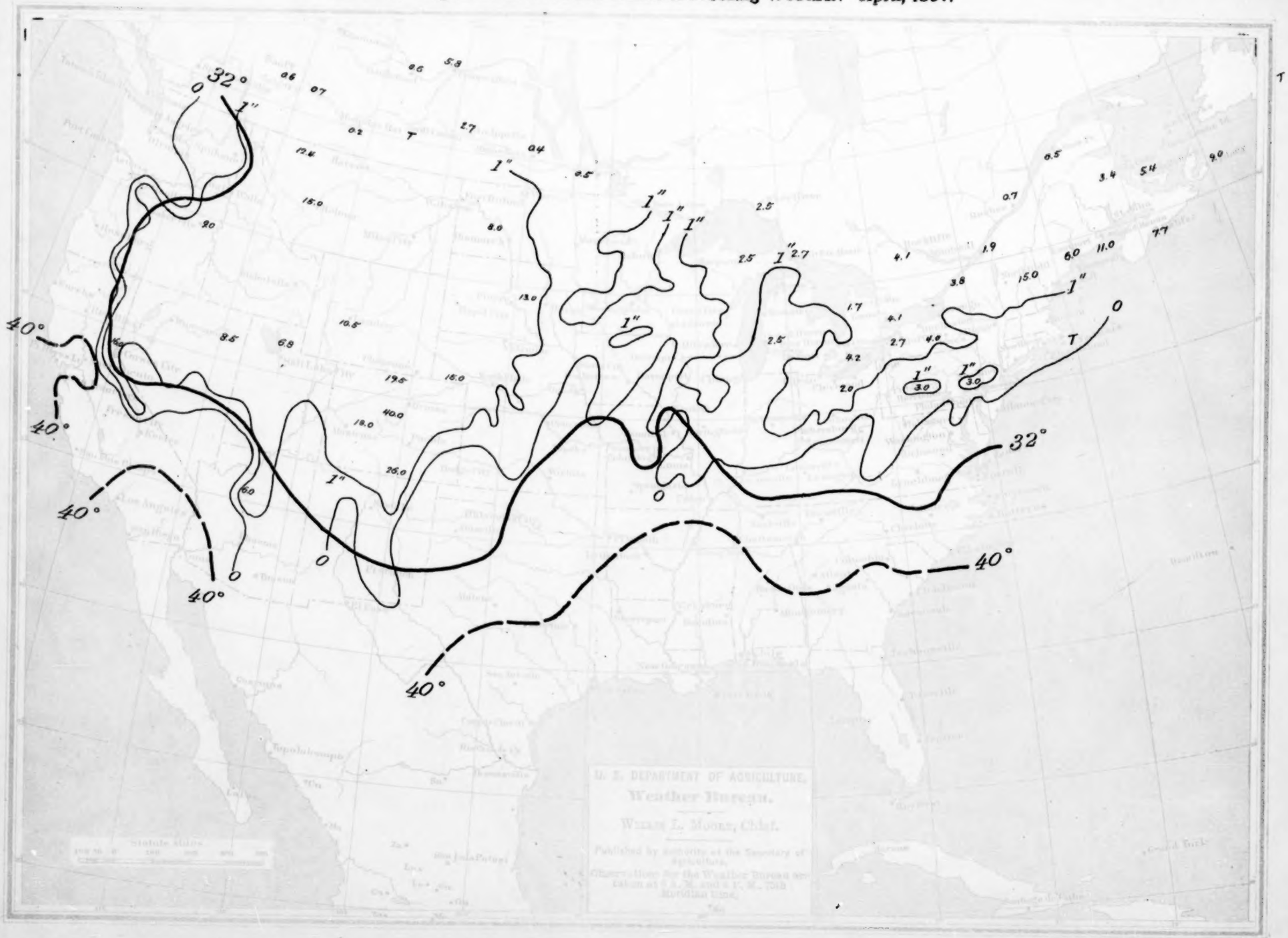


Chart VI. Hydrographs for Seve

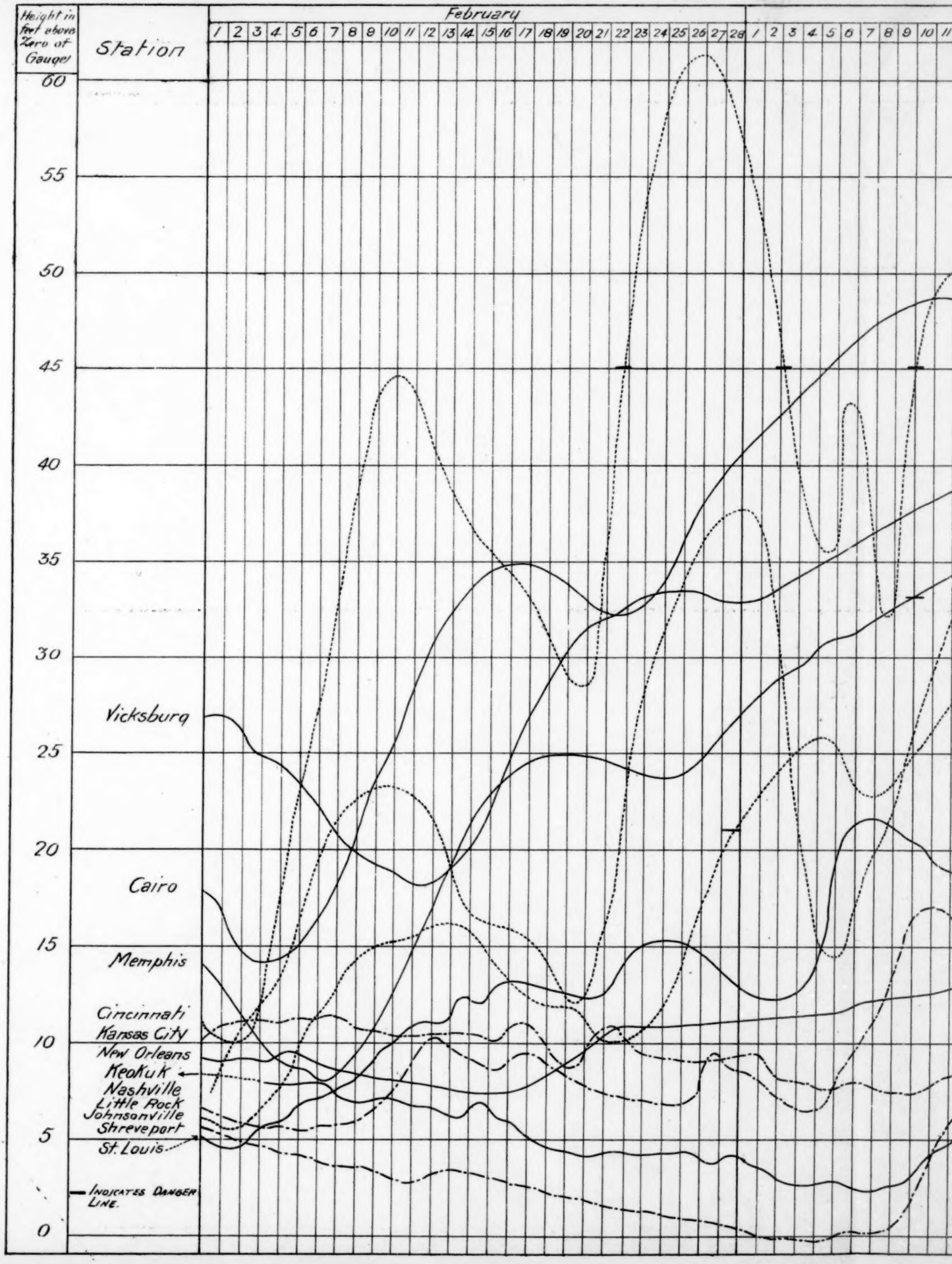
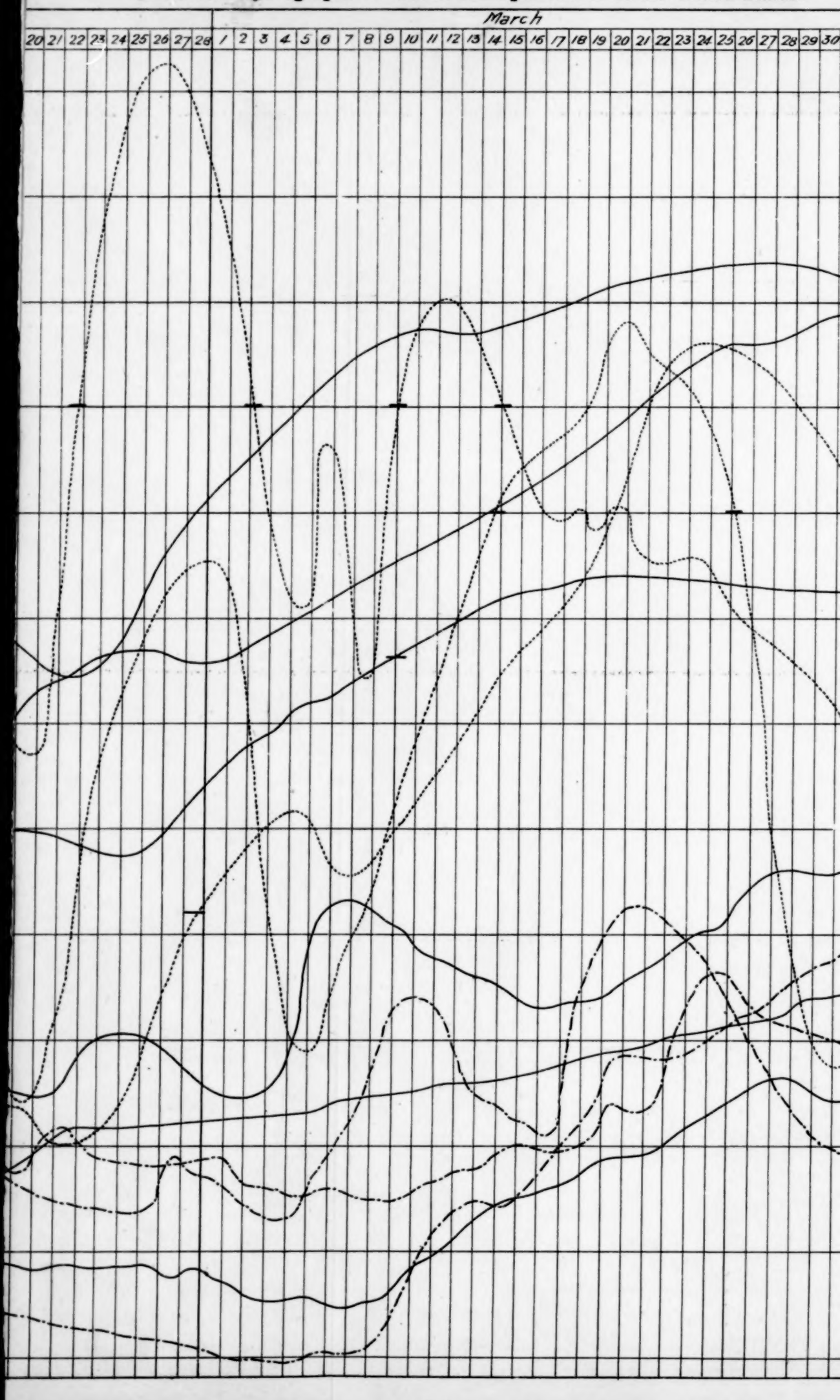
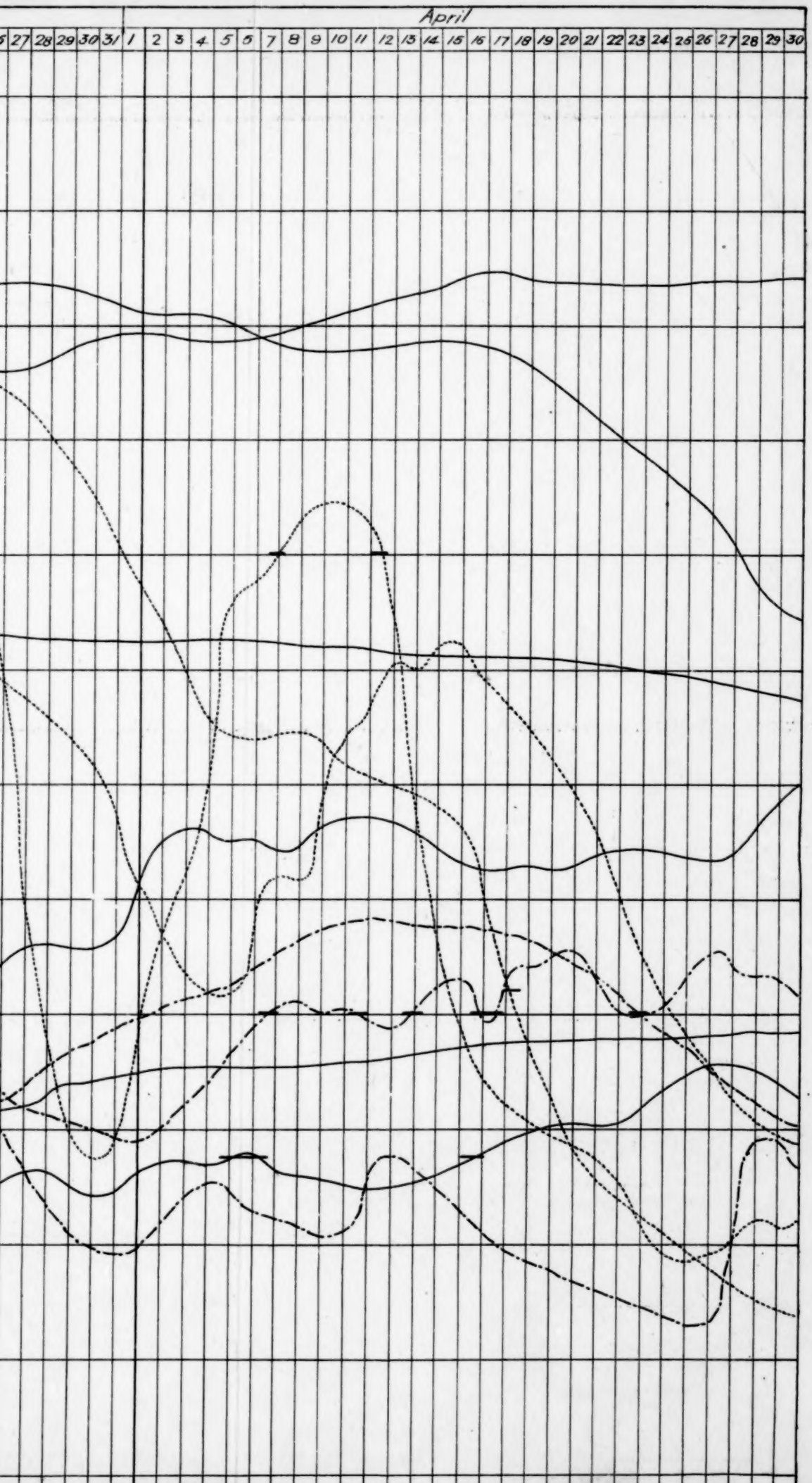


Chart VI. Hydrographs for Seven Principal Rivers of the United States.



States.


April
27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30